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Metacognitive self-regulated learning processes in computer and print reading assignments among elementary students in grades 2-5

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Self-regulated learning (SRL) and higher-order thinking (metacognitive processes) are important in education because they contribute to effective learning and improved academic performance. These processes may be facilitated by the implementation of computer technology in the classroom. This research project examined the use of computer technology among elementary school students and possible effects on self-regulated learning and metacognitive processes, including the ability to plan, monitor, evaluate one's own work, and apply specific learning strategies. Two main research questions were investigated: (1) Do elementary school students demonstrate SRL metacognitive processes when they use computers and paper-pencil for reading-relating tasks, and what are the key SRL metacognitive processes? (2) Are there differences in SRL metacognitive processes between computer-based and paper-pencil reading tasks in elementary grades?

Recruitment of students occurred at the local school district's after-school programs. A total of 52 students from Grades 2-5 consented to participate in two conditions, a computer-based and a paper-pencil reading task, each lasting approximately 30 minutes. Observations, ratings, and semi-structured interviews were conducted. The quantitative portion included descriptive and correlational statistics. Differences in SLR metacognitive constructs between conditions and between grades were explored. Inferential statistics employed a 2 x 4 (condition-by-grade) mixed-model Analysis of Variance and follow-up tests. The qualitative portion included primary analytic strategies, thematic analysis, and triangulation across data sources.

The results indicated that metacognitive self-regulated learning skills were present in students of primary grades. There were no differences between grades or between conditions for most regulation of cognition constructs except for control and evaluation practices. Among knowledge of cognition constructs, conditional knowledge was higher in the paper than in the computer reading assignment across grades. The qualitative findings corroborated the quantitative results. Students in primary grades demonstrated SRL metacognitive processes, and these were more common in the paper than in the computer condition.

These findings are explained by the familiarity with the reading medium, the integration of multimedia and verbal cues, the speed for corrective actions, and the use of prior knowledge. These important insights can contribute to improved academic performance and higher order thinking among young students. The results also suggest that students can benefit from focused instruction to perform transfer of knowledge between the two reading formats – computer and paper.

DEDICATION

To my family and to all who wish to be lifelong learners.

“Keep Ithaka always in your mind.
Arriving there is what you're destined for.
But don't hurry the journey at all.
Better if it lasts for years,
so you're old by the time you reach the island,
wealthy with all you've gained on the way,
not expecting Ithaka to make you rich.
Ithaka gave you the marvellous journey.
Without her you wouldn't have set out.
She has nothing left to give you now.

And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you'll have understood by then what these Ithakas mean.”

— *Constantine P. Cavafy*, excerpt from *Ithaka* (1911)

translated by Edmund Keeley and Philip Sherrard

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I know my family is extremely happy to see me reach this point – S and M and M, a smile was and is enough to keep me going. Σας αγαπώ.

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CHAPTER I

INTRODUCTION

Computer technology for instruction and learning has gained prominence in all educational levels and has become increasingly prevalent in public schools (South, 2017). Computer-based education empowers students for meeting the demands of the 21st Century classroom, which is characterized by fast-paced, readily-available, and efficient information. Computer-based education facilitates the work of teachers as they attempt to scaffold student learning with resources and supports (Yettick et al., 2016). It comes as no surprise that, across the United States, many states endorse computer-based education for developing student skills, such as problem solving, critical thinking, working collaboratively, and exercising self-awareness (Smith, 2016). Computer technology in education spurred at the moment where student agency in learning (that is a sense of control and choice) attracted attention (U.S. Department of Education, Office of Educational Technology, 2016). The integration of computer technology in schools not only has followed the rapid changes in information dissemination, but it has also caused systemic changes in information reception (Levin & Wadmany, 2006). Computer technology allows learners to have an active role in the process and use of learning strategies and supports instruction. In this way, students have the opportunity to exercise cognitive, metacognitive, and motivational mechanisms that contribute to effective learning and improved academic performance (Effeney et al., 2013; Kucuk, 2018). These mechanisms have been studied with a focus on innovative computer interventions and assessments for students of higher, secondary, and upper elementary education (Aleven et al., 2010; Bebell & O'Dwyer, 2010). However, how computers are used in early elementary grades has received little attention. There is a need to examine whether computer-based education has an effect on cognitive, metacognitive, and motivational experiences in primary school students of early and middle grades.

The Interplay of Cognitive and Metacognitive Processes with Computers

Computer technology allows students to be their own agents in learning and to assume an active role in what and when to learn. Classroom-based technology acts as a motivational, interactive, and learning tool for students (Belland & Drake, 2013). In particular, when educational technology incorporates multimedia and interactive techniques, it enhances learning skills and promotes cognitive development (Dalgarno & Lee, 2010; Mayer, 2003) such as augmentation of literacy and numeracy skills (Fiorella & Mayer, 2016; Robinson, 2016). Learning involves the process of arriving to conclusions through self-reflection. Incorporating that aspect into computer-based classroom environments implies that learners would have to assess the thought process of their conclusions. This thought process is nested in higher-order cognition, translated as metacognition and self-regulated learning (SRL). Metacognition is a person's ability to organize, monitor, and evaluate the cognitive strategies used (Brown, 1977; Flavell, 1979). Metacognition involves a person's active control and corrective actions while engaging in the process of self-regulating thought, including strategies for learning.

Metacognitive abilities can be enhanced through a variety of instructional practices, one as such being educational computer technology that creates scaffolds towards the construction of knowledge (Lin, 2001). Metacognition aids self-regulation because of continuous interaction of thought processes, control of the environment, and regulation of learning behavior. Thus, SRL –

the purposeful cognitive mechanism in the pursuit of a goal – has applicability in the context of educational computer technology, because the learner may seize opportunities to construct new learning with the use of computers (Bandura, 1989, 1991; Pintrich, 2003; Zimmerman, 1995).

Benefits of Computer-Based Education

The integration of computer technology in the educational environment can produce the following positive outcomes: change content delivery of teachers in ways that support autonomous learning for students (Storz & Hoffman, 2013); influence student behavioral, cognitive, and motivational outputs (Muis et al., 2016); promote interactive learning (Tatar et al., 2013); and allow accessibility of resources (e.g., equipment, software, curriculum supports) for teachers (Maninger & Holden, 2009).

The nature of these previously documented positive outcomes of computers may involve such higher-order skills as SRL and metacognition. These processes allow learners to plan, focus attention, remember instructions, monitor thoughts, control strategies, and evaluate tasks for achievement of goals in computer-based tasks (Efklides, 2011). Self-regulatory behaviors and metacognitive knowledge and experiences are associated with task completion (Malmberg, Järvelä, & Kirschner, 2014; Verpoorten & Westera, 2016). Students of younger age, in particular, demonstrate such skills in the form of reflection, monitoring, or learning strategies (Abrami et al., 2013; Malmberg et al., 2014a; Rutherford, 2017).

Disadvantages of Computer-Based Education

However, some scholars claim that the implementation of computers in the classroom produces negative cognitive and motivational consequences such as: taxed working memory that may contribute to cognitive load (Paans et al., 2018; Pratt & Martin, 2017); discontinuous engagement for high-achieving students (Serrano et al., 2018) that may lead to boredom and frustration (Artino, 2009); potential mismatch between student perceived and actual accuracy in performance tests (Pilegard & Fiorella, 2016); and digital distractions from non-educational online contexts (e.g. random web surfing; Cho & Littenberg-Tobias, 2016). These negative effects may interfere with metacognitive SRL, as these functions rely on working memory, mental flexibility, monitoring, and control (Hadwin et al., 2007; Kauffman, 2004).

Previous research suggests that computer technology, as a learning stimulus, may negatively influence the learner's ability to control strategies, manage distractions, and adapt attention (Panadero, 2017). It is also possible that individual differences between low- and high-achieving students hinder the use of SRL metacognitive strategies (Manlove et al., 2007; Roussel, 2011). Thus, computer interference may distract learners from processing new stimuli and from acquiring and retrieving new knowledge (Koriat, 2002; Storz & Hoffman, 2013).

Summary

The use of computer technology in the classroom may yield positive but also negative outcomes that may respectively facilitate or impair SRL metacognitive processes among students of elementary grades. Understanding whether computer use in early and middle elementary classrooms impacts SRL metacognitive and motivational dimensions among young learners and whether it yields successful student experiences requires further investigation.

Developmental Aspects of Computer-Based Education

Early development of SRL metacognitive and motivational skills may contribute to positive academic outcomes (South, 2017). When students monitor their behavior using computer feedback, this informs the use of learning strategies and impacts performance as data from think-aloud protocols and knowledge of cognition measures has shown (Deekens, Greene, & Lobczowski, 2018). Monitoring SRL equips students with skills for facing new content areas in computer-supported classrooms (Leelawong & Biswas, 2008). Past research suggests that metacognitive skills of third-grade students are still emerging, while metacognitive skills for fifth-grade students are nearly developed (Pratt & Martin, 2017; Roebers, 2014). This variability in findings of studies regarding metacognition may stem from measurement methods that pose challenges to the cognitive maturity of very young students, for example employing self-reported measures (Azevedo, 2015; Greene, 2015). Yet, research in non-computer environments indicate traces of self-regulation and metacognition in students as young as age 4 years, who reflect on problem-solving activities initiated by them (Robson, 2016). In the context of computer-enhanced school environments, SRL metacognitive processes including feedback prompts contribute to continuous engagement with tablets among kindergarten students (Muis et al., 2015). Further, first and second year primary school students have been documented to demonstrate self-monitoring and think-aloud behaviors in video cues of literary text (Pratt & Martin, 2017). Collectively, this body of literature suggests that computer-based educational environments have untapped potential for developing SRL metacognitive benefits in students.

Significance of the Study

Gaining insight into the relationship between computer use and SRL metacognitive and motivational processes in early and middle elementary school students may have practical implications. Such knowledge may assist teachers in creating computer learning environments conducive to SRL metacognitive and motivational strategies in young learners. The effects of computer-based education on SRL skills can be situated in one important domain for elementary school students: reading. Reading is a foundational skill for students to succeed through all the echelons of school life (U.S. Department of Education, National Center for Education Statistics, 2018). Reading competence may produce variation in outcomes—students may excel, or experience difficulties in early school grades (Anselmo et al., 2017; Stavridou & Kakana, 2008). Reading in different platforms – digital or print may also evoke different facets of cognition and metacognition (Halamish & Elbaz, 2020; Jabr, 2013; Koutsouraki, 2020). Nevertheless, the engagement or disengagement of students with reading tasks has further implications for achievement and future academic progress (Toshalis & Nakkula, 2012). Finally, competence in reading is associated with important early elementary assessments that fulfill basic Common Core requirements of the education system (Common Core State Standards, 2019). With the introduction of computers in classrooms across educational levels, it is important to examine whether the application of the SRL metacognitive framework may need to be expanded to early and middle elementary education. In addition, it is important the SRL metacognitive framework into a specific learning domain, particularly reading which is a foundational skill. Reading presupposes developing or developed metacognitive skills that assist students to extract meaning through conscious and controlled use of SRL strategies (Gough & Tunmer, 1986; Pressley, 2002). In this way, SRL may acquire domain and age specificity in school settings.

Research Questions

The overall objective of this proposed research is to investigate whether computer-based tasks have the potential to impact SRL metacognitive processes in students of primary grades (i.e., 2nd, 3rd, 4th, and 5th). To achieve this objective, mixed methodology of quantitative and qualitative techniques will be employed. The central hypothesis is that computer-based approaches are associated with SRL processes and improved student academic performance. More specifically, the proposed research will address the following two research questions:

1. Do early and middle elementary school students demonstrate SRL metacognitive processes when they use computers and paper-pencil for reading-relating tasks, and what are the key SRL metacognitive processes?

The working hypothesis is that most students will exhibit SRL skills while engaging in computer-related activities for reading. However, variability in student responses is expected; some students may use all SRL processes (i.e., setting goals, organizing, monitoring, evaluating), while other students may use only some or none of these processes.

2. Are there differences in SRL metacognitive processes between computer-based and paper-pencil reading tasks in early and middle elementary grades?

The working hypothesis is that computer-mediated tasks will produce greater effects on SRL skills than paper and pencil tasks, and these effects will be developmentally more prominent in older than younger students. This developmental effect occurs in older students because they have greater levels of self-awareness in using conscientious and intentional thought processes during learning, as develpmental psychologists have previously suggested (Chan, 2012; Connor et al., 2019; R. Garner et al., 1986).

Pursuing these specific research questions will produce important outcomes for the fields of educational computer technology and SRL. This study may aid in identifying whether elementary students employ SRL metacognitive processes. In addition, the study may provide evidence on the degree of agreement between actual SRL metacognitive skills of students when observed and when interviewed about using computers. This knowledge may be critical in developing computer educational programs tailored to the individual needs, interests, and aptitudes of students.

CHAPTER II

LITERATURE REVIEW

Metacognition and Self-Regulated Learning

Metacognitive processes are expressed through metacognitive knowledge and metacognitive experiences (Brown, 1977; Flavell, 1979). The role of metacognitive experiences is important in self-regulation because of the active monitoring of cognitive reactions to personal learning situations and personal characteristics (Brown, 1977). Metacognitive knowledge and metacognitive experiences differ—metacognitive knowledge is a product of memory monitoring of beliefs, actions, or strategies, whereas metacognitive experiences are a product of direct cognitive enterprises (Flavell, 1979). Furthermore, metacognitive experiences tend to be associated with task completion, whereas metacognitive knowledge involves regulation of past cognitive processes, as in prior knowledge, to produce successful output (Koriat, 2012). Finally, metacognitive experiences entail affective aspects, such as feelings of like/dislike, easy/difficult, accord/disaccord that a person undergoes in the pursuit of a task (Boekaerts, 1999).

Research on computer-based learning environments requires paying attention to cognitive, metacognitive, and motivational processes. These elements can be conceptualized under the theoretical perspective of SRL. SRL is the process of regulating cognition and behavior, leading to autonomous and effective learning (Panadero, 2017; Pintrich, 1999; Zimmerman, 1990). There are several models of SRL, but the present work will focus on the SRL model that derives from the social cognitive theory (SCT) and the theory of metacognition.

SCT views SRL as the ability of students to be active learners (Bandura, 1989). Bandura (1989) framed SCT in the context of cognitive, vicarious, self-reflective, and self-regulatory processes. In Bandura's view, personal agency influences these processes because it may act as an operational and deterministic mechanism that enhances or hinders self-efficacy in tasks of interest. SCT incorporates aspects of SRL in that SRL is a component of higher-order thinking and autonomous learning because it equips learners with awareness of their own abilities. Bandura (1991) also argued that students may pursue goals in a self-directed manner, using a combination of cognitive, motivational, and evaluative processes that would work within diverse social and educational contexts.

SRL and metacognitive processes involve the following elements: goal setting, organization, monitoring, and evaluation (Corno, 1994; Schunk, 2008). Goal setting is the development of desired actions that lead to specific objectives (Bandura, 1991). Organization entails the placement of desired actions into constructive categories (Kuisma, 2018). Monitoring involves feedback, strategies, and self-perceptions (Hadwin et al., 2007; Pintrich, 1999; Zimmerman, 1990). Monitoring affects control processes that, in return, translate into learning strategies (Nelson et al., 1994; Nelson & Narens, 1990). The learning strategies used in task completion rely on cognitive and memory functions (Koriat, 2002). Evaluation involves the mechanism by which a learner assesses if the desired goals have been met (Manlove et al., 2007; Zimmerman, 1989). Time management or the division of time for strategy use and task completion is an additional component of SRL (Schunk & Zimmerman, 1997). All these facets converge to higher-order cognitive abilities embedded in metacognitive skills, increase motivation, and contribute to effective learning strategies (Panadero, 2017; Schraw, 1998).

SRL metacognitive indicators can help us understand the ways scaffolding, modelling, feedback, and interactivity assist students while engaging in computer tasks (Bannert et al., 2015; Serrano et al., 2018; Sha et al., 2012). The integration of computer technology in education is important because computers can encourage transfer of prior knowledge (Bulu & Pedersen, 2012; Muis et al., 2015; Price & Oliver, 2007). Additionally, computers in education can positively affect memory and attention (Schacter & Szpunar, 2015), and influence the use of higher-order executive skills for goal attainment (Al-Jarrah et al., 2018). In the context of metacognition, the strategies of goal-setting, monitoring, control, and self-evaluation have been demonstrated during online courses for college students (C.-H. Lin et al., 2017), as well as in math-learning software (Dresel & Haugwitz, 2008) and problem-solving activities (Muis et al., 2016) for middle-grade schoolers. Further, motivational aspects of computer-mediated learning environments may stimulate student interest and engagement, and promote self-efficacy (Stevenson et al., 2017). Lastly, behavioral aspects can include persistence and task control that may lead to increased motivation (Malmberg et al., 2014b).

In summary, SRL involves the ability to make autonomous learning choices, to adapt goals to new circumstances, and to vary responses after receiving positive or negative feedback. SRL consists of a dynamic effort students make to discover and benefit from educational activities. SRL enables students to self-direct their actions not only at a metacognitive level, but also at a motivational level. The application of SRL in computer-based education can leverage cognitive, metacognitive, and motivational components, and provide a mechanism for augmenting effective acquisition of academic content and delivery of instructional practices.

Overview of the Literature

This literature review examines aspects of SRL and metacognition in computer-supported educational environments, from primary to tertiary education. The topics revealed developmental trends and aspects of metacognitive and SRL skills among learners as they interact with computers. The reviewed articles focused on the intentionality of using SRL metacognitive processes to plan, monitor, control, and evaluate learning goals. These processes are less well articulated in students of preschool and early elementary grades than students in older grade levels – middle, high school, even University. Computer-mediated learning can scaffold SRL metacognitive functions and allow for transfer of prior knowledge. Measurement tactics seem to play an important role in extracting surface or deep knowledge regarding the potential of computer-based educational settings. This literature review contributes to the existing evidence in the field of SRL metacognitive practices. The highlighted studies corroborate to a need for research designs that examine variation within age groups and effects on learning from routine use of computers for task completion. The insights gained from this discovery may extend students' computer use not only as tools for learning but also as tools for higher order thinking.

Metacognitive Skills

How do SRL Metacognitive Skills Develop in Children?

If we want to examine if and why children differ metacognitively and in their SRL skills, we must look at changes over time. Changes over time are important because they provide insights into children's metacognitive capacities and the age these appear. The literature on child development defines metacognition as experience-based and subject to between-subject variation (Flavell, 1979). Furthermore, cognitive psychology focuses on experiences as facilitators of cognitive regulation, with a focus on within-subject variation or individual differences (Koriat, 2002). Metacognitive skills follow a similar developmental trajectory with other cognitive skills (working memory and attention), subject to biological and social implications (Veenman & Spaans, 2005). Private speech, self-control, and self-instruction have also been identified as critical components in children gradually developing learning strategies, such as planning and regulating goal behavior (Harris, 1990; Pressley, 1979).

Research on first grade and third grade students indicates that metacognitive skills depend on intellectual ability (Schunk, 1986). Young children become aware of their basic metacognitive processes (memory and attention) before starting elementary schooling, at about age four (Roebers, 2014). However, application of metacognitive processes follows young children's school entry. For example, children in the age range of 7 years to 11 years start to realize that personal thoughts may interfere with task completion or information processing (Miller & Weiss, 1982).

Overall, past researchers argue that SRL metacognitive skills typically develop not earlier than 8-10 year-old children (Brown & DeLoache, 1977; Flavell, 1979). The notion of a late-developing skill is expressed in young children's difficulty to monitor their thinking during task performance and or to plan in selecting effective learning strategies for task completion. This difficulty is tied to memory development and the non-selection of mnemonic strategies. However, findings of recent empirical research have challenged past claims of late developing metacognition. For example, Whitebread et al. (2009) found in a two-year project that preschool children as young as 3-5 years old exhibited both metacognitive and self-regulatory abilities. The researchers relied on analyzing videotaped verbal and non-verbal indicators while children-initiated play activities using the Children's Independent Learning Development (CHILD 3–5) checklist. The observations revealed that preschoolers were capable of metacognitive activity during problem solving, including articulation of cognitive knowledge, cognitive regulation, and regulation of emotional and affective states.

In addition, Hennessey (1999) focused on the developmental nature of metacognition in 170 children in grades ranging from pre-K to 6. The project took place as a naturalistic case study (classroom setting) through individual and group discourse of metacognitive enhancing teaching activities. The findings showed that young students can produce metacognitive reflections in interactive (hands-on) classrooms tasks for a variety of domains. These reflections are translated into selecting correct strategies that lead to successful or desirable performance. However, the researcher acknowledged the fact that young children may not yet possess specific vocabulary to articulate their states of mind, a behavior that older children with metacognitive sophistication demonstrate clearly.

These past studies suggest that very young children can exhibit SRL metacognitive abilities in tasks that require active involvement. These abilities can be expressed less clearly in younger than older children, an issue often reflected in a study's methodological approach.

How are Reading Comprehension and SRL Metacognitive Skills Connected?

According to the "Simple View of Reading" (SVR; Gough & Tunmer, 1986), reading comprehension is enabled by the development of decoding and comprehension of spoken language. Decoding is automated through phonological awareness and consolidated through spelling (morphological awareness). When a student becomes fluent in reading, then comprehension of written speech is at the same or similar level as oral speech (Hoffman, 2009). Furthermore, semantic understanding of the words leads to the enrichment of the perceptual / receptive and active vocabulary (Hirsch, 2003).

Working memory, as well as short- and long-term memory influence cognitive functions that aid reading comprehension. Students in early elementary grades practice phonological awareness, syllable synthesis and word structure understanding in decoding automation. Constantly activating word formats through repetition increases the speed of access to long-term memory and thus recall is done almost automatically, with less mental effort (Graesser et al., 2003). Kirby & Savage (2008) used the SVR model to refer to the importance of spelling / morphological awareness as the next level of decoding, through which a faster recognition of words is established. Research suggests that teaching approaches to enhancing decoding through phonological and spelling awareness for automated word reading are based on repetition (Levy et al., 1993).

During reading, and comprehension in particular, students create mental representations of the text, which depend on and are influenced by their prior knowledge (van den Broek & Kendeou, 2008). Students with prior knowledge of the text are more likely to memorize it than those to whom the subject matter is unknown (Schwartz et al., 1998). Prior knowledge contributes to both comprehension and learning. The difference between learning and comprehension is clearly expressed by Kendeou et al. (2003) who define prior knowledge as the ability to utilize the knowledge gained from a text in similar textual environments and contrast it with the understanding of current knowledge and the ability to use that knowledge in new situations. The existence of prior knowledge is the expected source to which a student resorts to bridge the semantic gaps that, intentionally most of the time, an author leaves when writing the text (Cain et al., 2001; Graesser et al., 2001).

The most appropriate way for a student to extract meaning is through conscious and controlled use of reading strategies (Duffy, 1993), which presuppose developing or developed metacognitive skills (Pressley & Afflerbach, 1995). They are indicators of how the reader interacts with the text (Anderson, 2003). Many strategies come to replace and compensate for the "weaknesses" or difficulties of a reading text, e.g. when a student uses surface-level strategies such as underlining, connecting words, taking notes and then moves to using deep-level strategies such as rewording, context clues, diagrams, prior knowledge to facilitate the more demanding stages of comprehension (Dunlosky et al., 2013; Schwartz, 2016). Use, however, of surface- and deep-level strategies does not always ensure a complete and successful comprehension level, since the reading result is a function of other parameters and conditions (inherent difficulties of the text, unfamiliarity with the topic, cognitive ability, objective and subjective reading conditions, etc.) In that sense, it is beneficial for students to receive instruction about metacognitive strategies tha aid reading comprehension.

How are SRL Metacognitive Skills Manifested in Educational Environments?

Demonstration of any developmental effect in planning and strategy use is sensitive to subject-task interaction. Efklides (2011) focused on the difference between beliefs, abilities, and metacognitive skills at person-level versus task by person level, as these two products cultivate metacognitive control processes. In her Metacognitive and Affective Self-Regulated Learning (MASRL) model, Efklides analyzed the interaction between task by person level to show that personal characteristics such as self-beliefs, ability, and person-level metacognitive knowledge and metacognitive skills apply to a variety of tasks and a sense of when and how to apply them. The task by person level is where metacognition takes place: based on experience with a task, a learner may draw upon personal characteristics (self-dynamics) to engage control processes in metacognitive experiences. This concept applies to conscious and nonconscious learning processes which students may misinterpret and teachers may falsely expect.

The nature of metacognition lies on memory abilities. Not surprisingly, the application of SRL metacognitive skills for learning has attracted the interest of memory psychologists. Nelson and Dunlosky (1991) proposed the Monitoring-Dual-Memories model according to which the retrievable information enters short-term memory and that adds noise to a learner's monitoring of information and subsequent judgements of learning. The researchers examined the model on college students using word pair associations. Their conclusions indicated that immediate retrieval may tap simultaneously short and long-term memory, which can have practical applications in study strategies and increase the efficiency of cognitive activities. Son and Metcalfe (2000) proposed the idea of learners' using their metacognitive judgements to indicate what they know, which they subsequently use to control their own learning. These metacognitive judgements may rely on factors other than cues, such as extracting information for verbatim recall, the type of materials, interest (motivation), and time pressure. The authors conducted three experiments in relation to metacognitive control strategies in a study-time-allocation paradigm. When participants of the study felt they were under time pressure, they allocated more study time on easier items. Conversely, when participants felt free of time pressure they allocated more time to the judged difficult items. These findings show that time pressure, learning goals, and interest play a role in metacognitive learning strategies, which are also manifested in completion of reading tasks (Pesout & Nietfeld, 2020).

Metacognitive abilities can be enhanced through a variety of instructional practices that create scaffolds towards the construction of knowledge (Lin, 2001). Lin, in reviewing approaches to support metacognition, discussed opportunities for students to self-assess their knowledge and skills. She also pointed to metacognitive activities that help students articulate their own thinking. Such activities can be facilitated by different technologies that prompt learning. In that context, metacognitive strategies in SRL can have great applicability in computer-mediated classroom environments. Computer-mediated tasks evoke interactive learning, feedback support, self-evaluation, and engagement. All these components can lead to monitoring and control (Azevedo & Hadwin, 2005).

How are SRL Metacognitive Skills Measured?

Components of metacognitive SRL have been measured mostly with self-reported questionnaires and prevalently in college students (Alexander, 2008; Sperling et al., 2012). These two approaches have been found to offer cost-effective, easy to administer accounts of SRL processes and score assessments. However, from an operant perspective, it is important to understand the way learners use knowledge and specific strategies as a means of achievement in multiple educational settings (Meichenbaum & Asarnow, 1979).

Winne (2010) argues that measurement protocols about cognitive operations assess the product of these operations not the transition processes. For example, a learner who checks back her/his response to a problem solving task is an externalizing behavior to a prompt for doing so. Cognitive processes and their relationship with motivational orientations prompted Pintrich, Smith, Garcia, and McKeachie (1991) to develop the Motivated Strategies for Learning Questionnaire (MSLQ), a self-reported measure to college students. The MSLQ consists of a motivation section and a learning strategies section for a total of 15 subscales as predictors to students' academic performance. Within a decade, results representing more almost 20,000 college students showed variation in predicting student grades and effort regulation using the MSLQ, partly due to limitations in occasions and contexts (Credé & Phillips, 2011).

Recent efforts build upon younger populations and qualitative approaches such as diaries, observations, think alouds, and interviews to detect in-depth differences (Schmitz et al., 2011;

Thoutenhoofd & Pirrie, 2015). In addition, adaptations of the Metacognitive Awareness Inventory (Schraw & Dennison, 1994) to junior populations have contributed to measuring emerging metacognitive and self-regulated learning skills of students in elementary and middle grades (Sperling et al., 2002, 2012). The common threads in all measurement techniques are their self-reported nature, domain-general information that aim towards valid and reliable indicators of SRL and metacognition.

Computer-Based Educational Environments

The integration of computers in education purports the notion of equal access to information, personalized learning, and student achievement gains (Lowther et al., 2003; Penuel, 2006). Computer technology for educational purposes is important because computers can augment student learning and increase student engagement (Price & Oliver, 2007). A metasynthesis of 65 journal articles and 31 doctoral dissertations ranging from 2001 to 2015 revealed that computer environments in which students engage in one-to-one learning experiences significantly contribute to increased academic performance in science, writing, mathematics, and English (Zheng et al., 2016). However, computer-mediated learning environments may require extra pedagogic support in the form of learning management systems (e.g., online prompts and messaging) to facilitate metacognitive awareness, SRL, and knowledge sharing among students (Karaoglan Yilmaz & Yilmaz, 2019). Overall, computers in education have shown evidence of supporting students' academic performance following appropriate instructional cues to enhance goal-oriented behavior (Van Laer & Elen, 2019).

Metacognitive SRL & Computers

Planning – Monitoring – Evaluation.

Research on undergraduate students using trace data and log files from computer interactions has indicated student variation in SRL tactics (Hadwin et al., 2007). The results of that study showed discrepancies between what students perceive and actually do when use monitoring, strategy adaptation, and time management during computer engagement. On the other hand, high school students demonstrated more effective monitoring behaviors, when engaged in a hypermedia-learning environment for activities in history (Deekens et al., 2018). This resulted in increased use of deep SRL strategies, and was associated with a predictive validity between declarative knowledge and conceptual understanding. Hypermedia assignments in middle and upper elementary students have been associated with high cognitive load (Paans et al., 2018). Positive effects were demonstrated only on short-term metacognitive activities, such as orientating which implies transfer of prior knowledge. To compensate for the limitations of working memory by reducing cognitive load, early elementary students demonstrate the ability to develop higher-order metacognitive processes (e.g., monitoring and control) when engage in computer-enhanced reading activities (Pratt & Martin, 2017).

Collectively, these studies suggest that metacognitive processes are specific and sensitive to students' age. Computer learning environments can enhance these processes and help students succeed in task completion, when they reduce working memory load. Furthermore, computer-based reading may produce SRL strategies to compensate for the difficulties of a reading text.

Learning Strategies.

Evidence from the application of hypermedia environment for history learning indicated high levels of strategy use and monitoring, when high school students select a new informational resource and apply self-questioning techniques (Greene et al., 2010). A similar research vein revealed findings about organization strategies, with the placement of desired actions into constructive categories for middle school students when they digitally engage in geographic inquiry (Kuisma, 2018). On the other hand, correlational findings from two studies have shown no statistically significant relationships between monitoring and metacognitive strategy use in history (Deekens et al., 2018) and inquiry-based learning (Wilson & Narayan, 2016).

Researchers examining seventh-grade students' computer science achievement tests using MSLQ items found that organization and elaboration explained the most variation in scores (Akyol et al., 2010). When correlated with SAT scores, a moderate level of science achievement tests was observed. The results indicated that metacognitive strategy use in science classes promoted the processes of critical thinking, analyzing, problem-solving and decision-making but did not produce significant associations with metacognitive SRL. The researchers suggested the use of concept maps in science classes to promote frequent use of organization strategies and become part of students' study habits.

Overall, these results indicate that SRL metacognitive functions may vary across developmental domains. This variation may trigger different components of SRL to surface. In the case of reading tasks, learning strategies may be at a surface level (e.g., underlining, matching words, taking notes) or at a deep level (e.g., rewording, using context clues, creating diagrams, involving prior knowledge), contigent to the demands of comprehension.

Prior Knowledge and Transfer.

Past studies have shown that prior knowledge and advanced SRL skills provide resources for elaborated strategies (Lipko et al., 2009). Prior knowledge is also reinforced by findings indicative of more organization strategies in well-structured problems and of more critical thinking in ill-structured problems (Malmberg et al., 2014). Other researchers (Snow et al., 2015) have indicated indirect metacognitive awareness and metacognitive control in college students. During a game-based tutoring system, Snow and colleagues found that students were alerted of their poor performance and were then directed to a remedial activity. Students' scores improved during the transition process. However, there was no indication if the actual game-based tutoring system affected the increase of scores. The results of these previous studies have not been supported by a recent study that showed no differences of prior knowledge on planning and goal setting (Muis et al., 2016). In this study, Muis and her colleagues demonstrated that tablet-based teaching reinforced elementary students' learning, engagement, and concept mapping in mathematical problem-solving but produced no main effects when prior knowledge was used as a covariate.

Other instructional programs that facilitate self-explanation to get students learn are Cognitive Tutors. In a study of 41 students in 10th grade, Aleven and Koedinger (2002) examined the effects of a virtual Cognitive Tutor to scaffold self-explanation and deeper learning in problem-solving tasks. Students engaged in a series of tests including regular and transfer items where the software program provided hints and feedback. Regular test items consisted of computations, diagrams, and explanation with reasoning for a correct answer. Transfer items included judgements of learning about correct information in student's own words. Learning effects were greater for the items that involved explanations, with students spending more time in each item since they had to explain the solution steps. This research suggests that self-explanation, a type of SRL activity, may lead to deep understanding during guided learning.

Some years later, Kim, Park, and Baek (2009) explored the role of metacognitive strategies, such as self-recording (writing), modeling, and thinking aloud in problem solving situations. The researchers used a Multimedia Online Role Playing Game (MMORPG: Gersang) that provided scaffolding along with intrinsic motivation elements to 132 ninth-grade students. The findings from the path analysis showed that thinking aloud was the strongest strategy, followed by modeling in favoring achievement in socially interactive games. Writing was the least effective strategy in promoting achievement.

Overall, these metacognitive strategies could mediate cognitive skills in educational game-playing. Thinking aloud and modeling could transform into self-regulation in learning.

Reading and Problem-Solving.

Researchers have examined metacognitive SRL outcomes in computer-mediated language-learning enhancement activities. An intelligent tutoring problem-solving activity for reading comprehension in sixth and seventh grade students of low and high skill reading ability has produced varied results (Serrano et al., 2018). Specifically, low-skilled reading comprehenders produced greater statistically significant monitoring accuracy on their follow-up test than in their pre- or post-test. Conversely, their high-skilled counterparts exhibited no significant effects on pre-test and follow-up, but a significant effect on post-test. Furthermore, task-oriented reading using intelligent tutoring as treatment and traditional workbooks as control produced findings in favor of the computer environment. Additional studies have demonstrated increased self-regulated strategies through an analysis of computer mouse movements indicative of metacognitive activity in a foreign language course (Roussel, 2011), and through the use of podcasts for EFL learning among Iranian high-schoolers (Naseri & Motallebzadeh, 2016). This body of research suggests that SRL metacognitive ability in literacy tasks is associated with individual differences and domain knowledge, which computer engagement may accentuate.

Motivational Aspects of Computer-Mediated Metacognitive SRL

Self-Efficacy.

A cohort study by Pajares and Valiante (2002) revealed developmental aspects of SRL in 1,257 students from Grades 4 to 10 (age range 9 to 15 years old). The authors examined students' self-efficacy for SRL strategies (e.g., time management, self-monitoring) in language arts, using Bandura's Children's Multidimensional Self-Efficacy Scales. In addition, teachers' perceptions of students' academic competence in language arts were investigated using an A to F scale that mirrored grading. Grade and gender differences were also examined and analyzed with multivariate analysis of variance (MANOVA). The results showed that students' self-efficacy for SRL and for language arts decreased from 4^{th} to 7^{th} grade but stabilized after that point. Furthermore, self-efficacy was higher for female students. Gender and grade level differences persisted and were significant, even when teachers' ratings were added into the multivariate equation. These findings suggest a motivational disconnect between students' SRL practices and their academic competence. This low level of self-belief is reinforced as students transition higher in the educational ladder, which may impact future academic capabilities and career options.

Documented evidence of positive aspects of computer-based instruction focus on student behavioral, cognitive, and motivational outputs (Lowther et al., 2003; Muis et al., 2016). Lowther and fellow researchers (2003) conducted an intervention in fifth-, sixth-, and seventh-grade students to examine the impact of computer technology in writing and problem-solving skills. The design included a treatment (one computer per student) and a control group (multiple computers per classroom group), with descriptive observations of students. The results for the treatment group showed statistically significant results in all writing assessments and significant gains for the majority of the problem-solving tasks, indicating ease of using computers as a learning tool. Furthermore, positive effects were slightly higher for earlier grades (5th and 6th), indicating younger students eagerness to participate in computer tasks.

Measures of Computer-Mediated SRL Metacognitive Skills

Qualitative Measures

In the literature, researchers have used a qualitative approach to measure computer-based SRL, including discourse analysis of virtual learning interactive communities (Delfino, et al., 2008), triangulation of interviews from elementary and middle school students, teachers, and administrators (Underwood & Banyard, 2008), and case study for primary school students (Pratt & Martin, 2017). Other qualitative methods included the analysis of open-ended questions to capture students' emotions and perspectives (Tatar et al., 2013). In a similar path, transcriptions of students' speaking aloud utterances showed that student engaging in a hypermedia-learning environment contributes to deep-strategy use (Deekens et al., 2018). Last, one additional study with a qualitative methodology incorporated the narrative inquiry in adolescents to deeply understand the SRL process in a geographic educational course (Kuisma, 2018).

Quantitative Measures

Quantitative research is a prominent methodology in the study of SRL. Various ways to measure SRL include the use of cognitive ability questionnaires for applying study strategies, problem solving, and critical thinking, metacognitive aspects of knowledge and regulation of cognition, and motivational aspects of self-efficacy (Naseri & Motallebzadeh, 2016). Supplementary instruments, such as self-reflection journals where recall and editing of responses alleviate validity concerns raised by the use of self-reported measures. Other studies have included a computer-simulation learning environment in which researchers employed an experimental and control condition (Manlove, et al., 2007), or a study environment that solicited the use of eportfolios (Meyer, et al., 2010). Furthermore, measurement accounts through the use of Item Response Theory (IRT) Rasch polytomous methodology (Ferreira, et al. 2017) revealed that treatment students working in a SRL computer-supported instructional environment produced more accurate self-reflections than students in the control group.

Another trend in quantitative methodology is the use of targeted educational games in the form of interventions. Many researchers have used educational games or specific software to target SRL behavior. Under the model of SRL metacognitive strategies, studies have incorporated science and problem-solving through "Alien Rescue" (Bulu & Pedersen, 2012), and monitoring learning through "Betty's Brain System" (Leelawong & Biswas, 2008). Additionally, researchers have investigated content- and grade-specific computer applications, including ill- and well-structured tasks through the "gStudy" (Malmberg et al., 2014a), a mathematics online learning environment for Grades 2 to 5, through the "ST Math" (Rutherford, 2017), for Grade 6 through "MatheWarp" (Dresel & Haugwitz, 2008), or question comprehension through the "Read&Answer" software (Vidal-Abarca et al., 2010). Other evidence includes the use of the electronic portfolio "ePEARL" to support the cyclical phases of SR in bilingual courses in fourth to sixth grade students from Canada (Meyer et al., 2010). And most recent work investigated artificially intelligent tutoring programs that provided hints and feedback and recorded logging behavior of middle school students engaging in algebra tasks (Pilegard & Fiorella, 2016).

Summary

SRL metacognitive processes are intentional ways to assess goals for task completion. Prior knowledge and transfer ability to multiple domains and settings may assist with these processes. The developmental literature indicates that awareness of metacognitive skills may start at preschool age. However, applicability of metacognition comes into effect at school age as students learn to associate higher order thinking with ability to demonstrate this function. Limitations from very young students' verbal capacity and measurement turn researchers to seek understanding through alternative learning tools and methodological approaches, one as such being computer-based learning.

Rationale for the Study

The reviewed articles corroborate findings regarding SRL processes and metacognitive strategies. Engagement in monitoring behaviors demonstrate better use of SRL strategies (Deekens et al., 2018) that, in return, better prepare students to face new content areas in computer-supported environments (Leelawong & Biswas, 2008). Researchers have also exhibited variations in use of SRL strategies by familiarity of a task (Malmberg et al., 2014), or understanding of a task (Lipko et al., 2009; Underwood & Banyard, 2008). These findings suggest that operational definitions and prior knowledge may be necessary when proceeding with a study on SRL in computer-mediated classrooms. In terms of measurement, self-reported questionnaires pose limitations in providing a comprehensive view of SRL constructs (Naseri & Motallebzadeh, 2016). Drawbacks in methodology can potentially be alleviated by the use of multiple methods that offer multi-dimensionality in perspectives (Gašević & Azevedo, 2019; Greene, 2015).

Further research can focus on a comparison of computer-based versus paper-and-pen tasks to detect impact and variation of students' SRL and metacognitive practices (Bulu & Pedersen, 2012; Roussel, 2011). Particulalry in the domain of reading, the most appropriate way for a student to extract meaning is through conscious and controlled use of reading strategies, which presupposes developing or developed metacognitive skills (Koutsouraki, 2020; Pressley & Afflerbach, 1995). Furthermore, researchers have shown a relationship between reading comprehension and increased SRL practices (C.-M. Chen et al., 2019; Q.-S. Chen, 2009). Other important variables in expanding SRL processes and metacognitive strategies in computer-based educational environments could be scaffolded supports to increase ability (Serrano et al., 2018; Vidal-Abarca et al., 2010), as well as degree of students' task transfer of prior knowledge (Manlove et al., 2007; Shen & Troia, 2018). Additionally, research in early elementary grades can potentially produce further accounts about the sensitivity (prone to stimuli) and specificity (prone to domain) of metacognitive evaluation processes (Rutherford, 2017), and their effects on student performance (Muis et al., 2016; Paans et al., 2018).

From a methodological perspective, qualitative research has a lot of potential because it can offer insights to students' perceptions and behaviors (Ferreira et al., 2017). Specifically, observations and in-depth interviews can produce deep explorations and generate important accounts of SRL metacognitive practices in computer-supported classroom environments (Postholm, 2011; Robson, 2016).

The current study is an attempt to increase our understanding of student awareness and intent to use metacognitive SRL strategies in computer-based classrooms. A developmental approach is an important aspect of this study that includes a within- and between-subjects design to record metacognitive SRL performance. As previous studies have revealed (Gašević &

Azevedo, 2019; Greene, 2015; Molenaar et al., 2012; Muis et al., 2016), to measure metacognitive SRL ability in young elementary students, researchers need to employ a combination of methodological mechanisms, including task-specific interviews, observations of external SRL behaviors, and semi-structured surveys. The current study aims to provide qualitative and quantitative insights in a developmental context of SRL and metacognitive practices that can expand our knowledge of computer-based reading applications in education.

CHAPTER III

METHODOLOGY

Epistemological Paradigm

This study followed a mixed-methods design (McMillan & Wergin, 2010) which provided complimentary quantitative and qualitative insights (Johnson & Onwuegbuzie, 2004). Creswell and Plano (2010) have described the philosophical assumptions of the mixed-method design. According to these theorists, the mixed-method design provides answers to quantitative questions with positivist origins (e.g., “which strategies do students use to monitor their learning performance when using computers?”). Quantitative questions provide descriptive information and contribute to making inferences about a target-population. Qualitative questions aim at understanding reality using subjective perspectives. Qualitative inquiry is dense in detail and purposeful in examining a topic. The combination of quantitative and qualitative approaches in mixed-method design provides diversity in data sources and methodologies for achieving pluralism of views (Creswell & Plano, 2010). This diverse and pluralistic approach falls under the umbrella of pragmatism (Johnson & Onwuegbuzie, 2004). Pragmatism embraces features associated with positivism and constructivism, but it goes beyond the principles of each doctrine (Tashakkori & Teddlie, 1998). In accordance with the pragmatist paradigm, the mixed-methods design of the present study explored: (a) the social cognitive perspective that attests to social experiences (the computer-based experience); (b) self-regulated learning abilities (what students do to achieve a goal); and (c) metacognitive processes (students' conscious cognitive actions).

The quantitative component included rating scales on SRL metacognitive practices in computer-based and paper-pen reading tasks. Rating scales reflected pre-existing constructs and sought to measure and compare SRL, metacognitive skills, and self-efficacy in computer-based and traditional paper-pen-based reading tasks.

The qualitative component included semi-structured interviews and observations. Semi-structured interviews captured subjective accounts of participant perspectives and attitudes. The reasons for conducting semi-structured interviews were: (a) to gain a deeper level of detail by developing individual rapport with each participant; (b) to eliminate dominating or distracting voices, thus allowing a variety of perspectives and ideas to surface. In addition, observations provided direct evidence about students' computer- and paper-based SRL metacognitive practices. Observational data were collected using a checklist of SRL metacognitive items.

The mixed-methods design followed a concurrent triangulation scheme, where observations, ratings and semi-structured interviews were conducted at the same time (Creswell & Plano Clark, 2010; McCrudden et al., 2019). In this design, the qualitative data expanded the quantitative data to provide further insights. During the data analysis phase, findings were compared for integration of interpretations. Furthermore, research assistance from trained undergraduate students contributed to the triangulation of methods and data and worked against internal threats to validity, such as small sample size or researcher bias (Tashakkori & Teddlie, 1998).

The following sections describe the methodological approach in answering each of the research questions.

Research Approach to Research Questions 1 and 2

Research Question 1: Do elementary school students demonstrate SRL metacognitive processes when they use computers and paper-pencil for reading-relating tasks, and what are the key SRL metacognitive processes?

Research Question 2: Are there differences in SRL metacognitive processes between computer-based and paper-pencil reading tasks in students across elementary grades?

The research questions were investigated quantitatively using the self-reported rating scales. The research questions were also investigated qualitatively using the observation checklist and researcher notes in observations, as well as students' self-reported accounts in interviews.

Sampling and Recruitment

Non-probability sampling was applied, using a convenience sample of elementary students from two after school programs that met in different locations in the local school district. The first after-school program (AF1) was fee-based, served students pre-K to Grade 5, and operated 5 days a week during the school calendar year. AF1 provided recreational and enrichment activities to students through interaction and play. The second after-school program (AF2) was grant-funded through the 21st Century Community Learning Centers program. AF2 was free, served students Kindergarten to Grade 5, and operated during the school calendar year, 3 days a week with an emphasis on academic tutoring. The selection of the two after-school programs provided access to elementary students in non-school hours thus allowing no interference with regular instruction and increasing chances of participation. The study met all standards and ethical guidelines for research with human subjects and children. Following approval of the study from the school district and the MSU Institutional Review Board

(Appendix A), the researcher contacted administrators and teachers in each after-school program and, subsequently students' parents. Out of 156 total parents contacted (including those that received reminders), 69 agreed to have their children participate (42% return rate). The participation rate for students from AF1 was 43%, whereas for students from AF2 was 11%, forming a combined average rate of 27%. Written permission was provided from all parents and written assent from all children (see Appendix A). In the beginning of spring, the COVID-19 pandemic imposed a total school lockdown as a safety precaution. Consequently, all schools and after-school programs in the school district closed and the study was discontinued. Up to that point, data had been collected for 52 out of the 69 consented students in Grades 2-5.

Sample

The sample consisted of 52 students in Grades 2-5. Students were from 32 different classrooms with different teachers from the local school district - second grade: 7 classrooms; third grade: 12 classrooms; fourth grade: 7 classrooms; fifth grade: 6 classrooms. Due to the COVID-19 shutdown, four students only completed half of the study. Qualitative findings described actions and statements from all 52 students, whereas quantitative results were based on 48 students who had full data. G*Power analysis (Faul et al., 2009) was calculated to compute the required sample size. A-priori power analysis for the within-subjects effect indicated that, in order to detect a medium-sized effect that corresponds to partial eta squared = .06 (Cohen's f = .25) with 84% power in a repeated measures Analysis of variance (ANOVA; four grades by two conditions, alpha = .05, non-sphericity correction = 1), the researcher would need 36 participants. A power of 84% represents an accepted minimum level according to theorists (Cohen, 2013; Lakens, 2013). Post-hoc calculation based on the acquired sample size of n = 48 showed an average power of 82% (ranging from 5% to 99%), for the within-subjects effects in the 2 x 4 within/between factorial design ANOVAs.

Additionally, the final sample size met the criterion of theoretical saturation for the qualitative portion of the study and the underlined theoretical associations (Baker & Edwards, 2012; Saunders et al., 2018). Saturation was achieved when codes, themes, and theoretical components were repeated and no new elements of relevance were revealed through additional data collection (Glaser & Strauss, 1967; Saunders et al., 2018).

Participants.

Participants' age ranged from 7 years old to 11 years old (M = 9.06, SD = 1.21; 62% boys.) The racial profile of participants indicated African-American 29%, Asian 6%, and White 65%. For socioeconomic status, the researcher used as a proxy participation in the free or reduced lunch program which revealed 21% of students received free lunch, 4% received reduced lunch, and 75% paid for their lunch (Table 1)[1].

Table 1

Demographic Profile of All Participating Students in Grades 2-5 (n = 52)

Demographic Profile	2nd grade Count (%)	3rd grade Count (%)	4th grade Count (%)	5th grade Count (%)	Total Count
Sex					
Boys	6 (67%)	9 (64%)	12 (71%)	5 (42%)	32
Girls	3 (33%)	5 (36%)	5 (29%)	7 (58%)	20
Race					
African-American	3 (33%)	5 (36%)	2 (12%)	5 (42%)	15
Asian-American	0 (0%)	0 (0%)	2 (12%)	1 (8%)	3
European-American	6 (67%)	9 (64%)	13 (76%)	6 (50%)	34

[1] Based on national statistics, student eligibility to free/reduced lunch was 69.6% for the local school district in school year 2019-2020 (Institute of Education Sciences: National Center for Education Statistics, 2019).

Table 1 (continued)

Demographic Profile	2nd grade Count (%)	3rd grade Count (%)	4th grade Count (%)	5th grade Count (%)	Total Count
Free or Reduced Lunch					
Free	2 (22%)	3 (21%)	1 (6%)	5 (42%)	11
Reduced	0 (0%)	1 (7%)	1 (6%)	0 (0%)	2
Paid	7 (78%)	10 (72%)	15 (88%)	7 (58%)	39
Age Breakdown					
7 years	5 (56%)				5
8 years	4 (44%)	10 (71%)			14
9 years		4 (29%)	9 (53%)		13
10 years			8 (47%)	5 (42%)	13
11 years				7 (58%)	7

Students' self-reported average computer use at school was almost three days a week (*M* = 2.82, *SD* = 1.76) for about 45 minutes a week (*M* = 45.96, *SD* = 14.39), while paper and pen use was approximately five days a week (*M* = 4.45, *SD* = 1.14) for a little more than 100 minutes a day (*M* = 102, *SD* = 101.69). Table 2 shows average self-reported frequency and duration of computer and paper-pen assignment use by grade.

Table 2

Average Frequency and Duration of Computer and Paper Use at School in Grades 2-5 (n = 52)

Medium	2nd grade *M (SD)*	3rd grade *M (SD)*	4th grade *M (SD)*	5th grade *M (SD)*	Total *M (SD)*
Computer					
Frequency	3.11 (1.90)	2.00 (1.73)	3.29 (1.83)	2.83 (1.47)	2.82 (1.76)
Duration	41.88 (18.69)	50.83 (15.64)	48.44 (9.44)	40.50 (14.76)	45.96 (14.39)
Paper-Pen					
Frequency	5.00 (.00)	4.00 (1.53)	4.69 (.87)	4.27 (1.19)	4.45 (1.14)
Duration	78.75 (70.76)	126.67 (12.25)	161.25 (88.42)	109.50 (137.79)	102.00 (101.69)

Methodological Design

This study followed a mixed-method design in which qualitative and quantitative measures were combined to assess students' SRL metacognitive skills. In this study, we explored differences in SLR constructs between conditions (computer vs. paper reading) and between grades. Therefore, a 2 (conditions) by 4 (grades) design (within- / between-subjects) was applied. The between-subjects factor involved comparisons between students of four grade levels. The within-subjects factor involved the same students participating in two conditions: (1) reading – computer; and (2) reading – paper. Thus, each student served as a control of themselves. The benefit of this approach was that participant variance was minimized, which made it more likely to detect a real difference in SRL skills among conditions (Abrami et al., 2013). Another benefit related to using statistical procedures that removed error in the data from extraneous participant variables, such as exposure to computers at school (Zamora et al., 2018). One of the drawbacks of a within-subjects approach is practice or carryover effects that may pose a threat to internal validity (Field, 2013a). To reduce these effects, there was counterbalancing of conditions. One to two weeks intervened between the order of conditions, which further reduced any learning effects. In addition, the types of tasks were adapted to student's grade and followed a pacing guide for learning standards by grade, as provided by educators in the elementary schools that students attended. Table 3 shows the combination of groups with conditions with final participating students in each cell.

Table 3

Number of Final Participating Students by Grade and Condition (n = 48)

Grade Level	**Sex**	**Computer Condition**	**Paper Condition**	**Grand Total Row**
2	Boys	6	6	12
	Girls	2	2	4
	Total	**8**	**8**	**16**
3	Boys	8	8	16
	Girls	5	5	10
	Total	**13**	**13**	**26**
4	Boys	11	11	22
	Girls	5	5	10
	Total	**16**	**16**	**32**
5	Boys	5	5	10
	Girls	6	6	12
	Total	**11**	**11**	**23**
Grand Total Column		**48**	**48**	**96**

Measures and Survey Instruments

Operational Definitions

In this study, we explored six constructs in observations and ten constructs in interviews, all derived from the theory of metacognition – regulation of cognition and knowledge of cognition, and motivation. The regulation of cognition construct entails the following dimensions:

- Planning refers to organizational thinking and preparatory actions to fulfill a learning goal (Corno, 1994; Greene et al., 2010).
- Monitoring is the cognitive reaction that drives learning goals while regulating thought and behavior (Brown & DeLoache, 1977).
- Control refers to corrective actions, including strategies for learning such as organization of ideas, close reading, reading aloud, and retrying (Flavell, 1979).

- Evaluation involves the performance mechanism by which a learner assesses if the desired goals have been met (Pintrich et al., 2000; Zimmerman, 1989).

The knowledge of cognition construct entails the following dimensions:

- Declarative knowledge is the ability to recall facts and events and it requires conscious effort and explicit memory (Boekaerts, 1997).
- Conditional knowledge refers to knowledge about when and why to learn (Flavell, 1979; Schraw, 2006).
- Procedural knowledge refers to knowledge of applying certain procedures and learning strategies to achieve learning goals and it incorporates implicit memory (Winne, 1995, 2011).

Finally, three motivational constructs included:

- Technical skills – awareness and knowledge of navigating and completing reading tasks (Brown & DeLoache, 1977).
- Self-efficacy – the belief in one's ability to successfully realize their goals that contributes to self-confidence (Bandura, 1977, 1989).
- Reading motivation – engagement and preferences about reading (Wigfield, 1997; Wigfield & Guthrie, 1997).

Semi-Structured Interviews

Metacognitive Awareness Inventory

The researcher conducted semi-structured interviews with participants where both quantitative and qualitative data were collected. The Junior Metacognitive Awareness Instrument (Jr. MAI; Sperling, Howard, Miller, & Murphy, 2002) designed for younger students in Grades 3 through 8 was used as the basis for interviews. Jr. MAI was an adaptation of the original metacognitive awareness inventory (MAI), developed by Schraw and Dennison (1994) that consisted of 52 items in two subscales: (a) *regulation of cognition*, defined as the cognitive processes that facilitate control; and (b) *knowledge of cognition*, defined as the cognitive processes that facilitate reflection. The original MAI had high internal consistency ($\alpha = .93$ and .88 for *knowledge of cognition* and *regulation of cognition* subscales, respectively; Schraw & Dennison, 1994). Jr. MAI had a reported internal consistency of $\alpha = .76$ for students in early elementary grades (3-5) and $\alpha = .82$ for students in middle grades (6-8) (Sperling et al., 2002). Similar to MAI, Jr. MAI consisted of items associated with the two subscales of *knowledge of cognition* and *regulation of cognition.*

For the purpose of this research, items from Jr. MAI and the original MAI were used. Each subscale was adapted to reflect engagement with computer-based and paper-and-pencil tasks. Items were read to the students and sometimes rephrased to provide clarity. The subscale *regulation of cognition* included the following dimensions: planning (3 items); monitoring (2 items); control-learning strategies (3 items); evaluation (4 items). The subscale *knowledge of cognition* represented the following dimensions: declarative knowledge (4 items); conditional knowledge (2 items); and procedural knowledge (2 items). Three motivation dimensions were technical skills (3 items), self-efficacy (3 items), and reading motivation (3 items). Appendix B includes the rating scales and discussion prompts. Each item was scored as 0 = Never, 1 = Sometimes, and 2 = Always for students' SRL metacognitive processes. A total score for each dimension was calculated and the mean was used in statistical analyses. To describe students' reflections on SRL metacognitive processes and gain insights on certain cognitive and behavioral practices, we asked follow-up, open-ended questions (e.g., "Why do you say that?", "Why do you think does this happen?" or "Could you tell me more about that?").

Observations

An SRL metacognitive checklist was adapted to facilitate systematic observation of SRL, metacognition, and motivational constructs. The checklist included 3 items for technical skills; 3 items for self-efficacy; 2 items for planning, 3 items for monitoring; 7 items for control; and 2 items for evaluation. Each item was rated as '1' when a behavior was observed and '0' when a behavior was not observed, based on the original MAI by Schraw and Dennison (1994). Additional behaviors were recorded using researcher comments. Appendix B includes the SRL observation checklist and Appendix C frequencies of the items. The observations were conducted by the author and an undergraduate assistant, as a pair of raters. One to two weeks intervened between interrater sessions. Interraters were blinded to each other's results until data entry. Cohen's kappa (κ) was employed to calculate interrater agreement. Kappa coefficient corrects for rater agreement due to chance (McHugh, 2012). This calculation produced a coefficient of 0.84 for the computer condition ($p < .05$) and a coefficient of 0.53 for the paper condition ($p < .05$). These tests demonstrated almost perfect agreement for the computer condition and moderate agreement for the paper condition (Cohen, 1960; Conger, 2017).

Other Measures

Reading Motivation

Each computer and paper interface included three general, warm-up questions about reading motivation: "find reading interesting," "look forward to reading," and "find reading enjoyable." All three reading motivation items were scored as 0 = *Never*, 1 = *Sometimes*, and 2 =

Always to keep them consistent with the rating scale at the interview phase; the sum was calculated and used in analyses.

i-Ready Achievement Scores

In addition, i-Ready diagnostic reading scores were obtained from the school district to assess participant performance in reading. i-Ready diagnostic scores are in the range of 0-800 and cut-off scores are based on student's chronological grade level. Two data points in fall (M = 542.43, SD = 53.35) and winter (M = 560.49, SD = 53.69) represented participants' i-Ready diagnostic score. Table 4 shows reading proficiency ranges of i-Ready Diagnostic normative scores per grade as compared with i-Ready scores of students who participated in the study. The data indicated that participating students started below the threshold minimum but surpassed the threshold maximum at both time points.

Table 4

Score Ranges of i-Ready Diagnostic Test of Students in Grades 2-5

Grade Level	**i-Ready Range**		**Study Range**	
	Early (Fall)	Mid (Winter)	Early (Fall)	Mid (Winter)
2	491-515	516-536	442-624	440-655
3	514-547	548-560	444-622	493-622
4	557-578	579-602	480-624	511-655
5	581-608	609-629	454-663	464-676

Notes. i-Ready ranges represent on-level scores that students in Grades 2-5 should achieve to be considered proficient in reading. Study ranges represent actual minimum and maximum scores on i-Ready Diagnostic Test for participating students in Grades 2-5.

Procedures

Each student attended both sessions: Condition 1 – reading task using computer; Condition 2 – reading task using paper and pencil. The order of conditions was counterbalanced and separated by approximately 7 to 15 days. In each grade, half of students first completed the computer condition and the other half first completed the paper-pencil condition. Each participating student was observed and interviewed one at a time in the after school program of attendance. Four undergraduate students assisted with data collection in a rotating schedule where one undergraduate student assisted the principal researcher at each session. Memos from undergraduate students were included in the qualitative findings. In the computer condition, the researcher asked students to login to their i-Ready account to access an instructional reading assignment determined by students' teacher (see example in Appendix D). The researcher and one of the undergraduate students observed participants as they completed a reading assignment using the i-Ready online educational program, which aligns with Common Core Standards (Curriculum Associates LLC., 2019). In the paper-and-pencil condition, the researcher and undergraduate student observed participants as they completed a worksheet for reading. The worksheets included i-Ready reading assignments recommended by the Mississippi Department of Education (MDE) and the local school district for exemplar units and lessons (MDE, 2019a). The researcher followed a pacing guide for reading standards to ensure that paper reading assignments from the i-Ready instructional book were adaptive per school term and grade level. Regardless of condition, the researcher made available to students blank sheets of paper to make side notes (annotations) as they completed a task. Data collection occurred within a period of one to two weeks between conditions to reduce any potential practice effects.

During the computer and paper conditions, participants were observed for their technical skills (i.e., navigational and solving behavior), their think-aloud utterances and questions, their SRL metacognitive practices, and their completion time. These elements were recorded using a checklist of SRL practices adapted from existing measures (Jr. MAI by Sperling, Howard, Miller, & Murphy, 2002). Following observations, the researchers conducted self-reported interviews to ask students about their SRL metacognitive processes. Students responded to follow-up prompts in the metacognitive SRL scale and provided direct and retrospective accounts of knowledge and regulation of cognition. Direct and retrospective descriptions of behaviors and thinking processes complemented each other because the former related to a specific reading assignment given at the day of the study, while the latter corresponded to a reading assignment typically given at school. Rating scales and open-ended discussion items guided this process.

On average, computer observations lasted 12 minutes (M = 12.32 min, SD = 3.31 min) and semi-structured interviews lasted 17 minutes (M = 17.07 min, SD = 4.29 min); the average for the whole computer interface was 31 minutes (M = 30.46 min, SD = 4.03 min). For the paper condition, the averages were for observations 13 minutes (M = 13.01 min, SD = 4.34 min) and for semi-structured interviews 19 minutes (M = 19.05 min, SD = 5.25 min); the average for the whole paper interface was 30 minutes (M = 30.13 min, SD = 6.20 min). These average durations turned out to be less than original estimations. Two observations and two interviews occurred per day. All observations and interviews lasted almost six months, from the beginning of October 2019 to the beginning of March of 2020. Reading topics focused on reading comprehension or vocabulary, and varied from scientific ideas and literary texts to myths and elements of plays (Appendix E shows a sample list of reading category and topics per condition and grade.)

Quantitative Data Analysis for Metacognitive Self-Regulated Learning Constructs

Statistical analysis was conducted using SPSS 26.0 (IBM, Armonk, NY). Significance was determined at an alpha level of .05. The research questions were answered quantitatively using 2 x 4 (condition-by-grade) mixed-model ANOVA and follow-up tests as warranted. Independent variables were the condition (computer-based vs. paper-pencil) and grade (2, 3, 4 and 5). The mixed-model ANOVA was run separately for each dependent variable. Dependent variables were the total scores of SRL metacognitive processes as rated during the interview: (1) knowledge of cognition constructs (i.e., declarative knowledge; conditional knowledge; and procedural knowledge); (2) regulation of cognition constructs (i.e., planning; monitoring; control; and evaluation); and (3) motivation constricts (i.e., technical skills; self-efficacy; and, reading motivation.) There were some violations of normality but no violations of sphericity and no violations of homogeneity of variance. In the absence of significant condition-by-grade interaction, a significant main effect of grade was further analyzed with post-hoc Bonferroni tests between grades. When the condition-by-grade interaction was significant, paired-sample *t*-tests with Bonferroni-adjusted alpha (.05 ÷ 4 =.0125) were performed to examine differences between conditions for each grade. Additionally, the effect of grade was examined using within-condition one-way ANOVA and, upon significant main effect of grade, post-hoc Bonferroni tests. Effect sizes were reported as partial eta squared (η_p^2). Finally, the researcher ran independent samples *t*-test to investigate the possibility of using independent variables (i.e., gender, race, participation in free/reduced lunch program as a proxy for socioeconimic status-SES, and reading motivation) as covariates, but the results were not significant. This suggests that students of different demographic and SES characteristics exhibit similar SRL metacognitive processes in both conditions; therefore, no further analysis using covariates was conducted.

Qualitative Data Analysis for Metacognitive Self-Regulated Learning Constructs

Qualitative analysis was conducted using the NVivo 12 software (QSR International, Melbourne, Australia). NVivo is widely used in computer-assisted qualitative data analysis software (CAQDAS) applications (Leech & Onwuegbuzie, 2007). The data analysis plan involved the following stages: listening to audio recordings and transcribing them verbatim; reading through the transcripts to highlight comments or phrases representative of participants' perspectives; clustering of highlighted statements into summaries for generating domains of meaning; classifying data sources by type (e.g. semi-structured interviews, observation notes, researcher memos); identifying sections corresponding to a general concept or theme; and aligning the original codes with key SRL metacognitive processes in observations and interviews. Following transcription of interviews and compilation of memos and comments from observations, NVivo was used to organize these data sources into categories (interviews-observations), and create node classifications (codes) of each data source and case. In NVivo platform, the categories resulting from the coding process are referred to as nodes. Nodes are more than matching a comment to a title. In this study, nodes corresponded to constructs, or dimensions. First free nodes were produced for a range of items such as "enumerating the text lines," "hearing the animation characters," or "going back to the text." The free nodes were combined to create tree nodes for items of similar dimensions. Once all statements were coded into like nodes, nine major classifications (constructs) emerged that were important to the study (Gibbs, 2013). Analysing these data allowed for reflection on each construct; comparisons for similarities and differences between the two conditions were also made. Overall, the qualitative software provided flexibility and ease with the management of data sources, and the identification of key nodes.

Constant comparison served as the main analytical process during the qualitative data analysis. The empirical data were closely examined, new codes were constantly compared to earlier codes, and final codes were integrated to match the theoretical constructs used in the study. For this purpose, questions such as: "How can we understand this comment?" aimed to facilitate the coding process and provide meaning to researcher interpretations. Furthermore, the function of query was used to identify data sources and nodes based on a set of criteria posed by the researcher. Query formats came as text search, or word frequency search, or comparison of content between conditions. For example, the code “sound-out” appeared in 12 data sources, seven in the paper condition and five in the computer condition. The interpretive processes, performed during the creation of the nodes, allowed the researcher to constantly organize new meanings or new patterns of relationships in the data. As a result, the gained knowledge contributed to making theoretical attributions to the study of metacognitive SRL in computer and paper reading.

As codes integrated into the main themes, the researcher checked for additional sub-codes and performed axial coding to further collapse the data (Miles & Huberman, 1994). This process allowed for clustering codes into tree nodes in a hierarchical structure, thus identifying all nuances of the codes. In addition, the researcher cross-referenced codes with all data sources and memos in order to conduct deep exploration of the data. The primary analytic strategies used were those of thematic analysis and triangulation. The researcher reviewed coded sections and looked for emerging themes across data sources according to the constant comparative method (Corbin & Strauss, 1990; Glaser & Strauss, 1967). Then, the researcher checked for converging or conflicting findings by groups of participants, and collection method (triangulation). Finally, a conceptual map was created to aid in contextualizing the findings. Appendix F includes raw qualitative data by construct, condition, and grade to aid readers’ understanding of concepts.

Rigor in Mixed Methods Research

Psychometric Properties of Quantitative Data

Internal Consistency

Reliability of the measures was evaluated by examining the internal consistency of the combined scales and each subscale using Cronbach's alpha (Cronbach, 1951; Furr, 2018). If the items inter-correlated well, then Cronbach's alpha would be high. An $\alpha > .70$ would be considered good to excellent (Cronbach & Meehl, 1955). The results of the internal consistency calculations showed that the "knowledge of cognition" subscale was close to acceptable with $\alpha = .68$ for the computer condition and questionable with $\alpha = .57$ for the paper condition. On the other hand, internal consistency calculation for the "regulation of cognition" scale was close to acceptable with $\alpha = 0.66$ for the computer condition and good with $\alpha = .72$ for the paper condition. Last, motivation constructs generated acceptable internal consistency for the computer condition, $\alpha = .71$ and marginal internal consistency for the paper condition, $\alpha = .65$. These results posit an internal limitation of the instrument, reflective of the few items in each sub-scale (Field, 2013b; Taber, 2018). Another explanation for the low internal consistency results can be attributed to the cognitive depth of the scale items, which may be above the knowledge level for students in Grades 2-5. Appendix G shows internal consistency results for all combined and individual constructs.

Construct Validity

The instruments contained parallel items that measure SRL metacognitive constructs under different conditions. Therefore, the design offered the opportunity to evaluate two aspects of construct validity: convergent validity and discriminant validity. Convergent validity refers to how much different assessments measure the same constructs, whereas discriminant validity refers to how much different methods diverge (do not interrelate) in their measurement of different constructs (Cronbach & Meehl, 1955). Convergent validity and discriminant validity was evaluated by examining bivariate correlations among examined constructs in each proposed condition (i.e., computer and paper). The sum of each construct was treated as a continuous variable; therefore, the researcher determined that a Pearson correlation was the appropriate statistical test to use for bivariate correlations.

The results for the combined constructs (i.e., regulation of cognition, knowledge of cognition, and motivation) indicated low to moderate, statistically significant, positive correlations ($r > .30$, $p < .05$; Appendix H). These results imply two things: (a) a direct relationship between the SRL metacognitive variables; (b) convergence of correlation coefficients that represent related constructs. However, correlations did not attest to discriminant validity because there were no low correlations for measures of different constructs. Therefore, the criterion of construct validity was only partially fulfilled.

Trustworthiness and Authenticity of Qualitative Data

There are two major sets of criteria to evaluate the quality and rigor of qualitative research: *trustworthiness* and *authenticity*. Trustworthiness in qualitative inquiry is to establish confidence in the truth of the research findings, as expressed through four criteria: credibility (or internal validity); transferability (or external validity); dependability (or reliability); and confirmability (or objectivity; Guba, 1981; Guba & Lincoln, 1994; Kornbluh, 2015). Triangulation of methods was employed to achieve transferability of conclusions and thus, trustworthiness (Shenton, 2004). These methods included field observations, rating scales, and semi-structured interviews. Furthermore, analyzing the findings with a qualitative analysis software allowed for establishing valid connections between theory and data. Credibility was also ensured by instantaneous checking of data accuracy as previously recommended (Shenton, 2004). Finally, dependability was addressed through the researcher's personal reflections in memos and audit trails on the effectiveness of the research proposal and implementation. The researcher performed the following procedures to ensure trustworthiness: (a) triangulated the sources - observations and interviews; (b) employed multiple raters in each condition; (c) matched the data with pre-determined theoretical constructs and created additional codes for emerged themes; (d) engaged with the data through a prolonged analytic process and the writing of thick descriptions; and (e) applied member checking of behaviors observed with statements in interviews.

Authenticity is to represent the original research objectives and maintain a consistent demeanor when interviewing others (Yin, 2011). The approach to ensure authenticity involved original and emerging open-ended questions to account for evolving themes and definition of constructs in the form of a codebook for common understanding of constructs. Also, a critical appraisal of the evidence (e.g. quotes) and interpretations provided authentic reports of participant views (Guba & Lincoln, 1994; Morrow, 2005).

Measures Against Researcher Bias

To combat against researcher bias, students were treated as active participants with their own voice (Howitt & Cramer, 2011). The researcher guided the conversation using simplified language and specific prompts in an effort to draw deeper information (thoughts, beliefs) from student participants during the interviews. Moreover, the implementation of ethical guidelines in human research allowed for student participation at own free will using the assent form and ensured students' anonymity when analyzing and reporting the results. Also, employing additional research assistants and utilizing their qualitative memos and comments contributed to increased trustworthiness and credibility of the collected data. Finally, to eliminate traces of implicit bias the researcher engaged in self-reflection and self-questioning to extract information from all possible angles and generate fairness in participants' voices (Wilson, 1998).

CHAPTER IV

RESULTS

Quantitative Results

Overview

Quantitative data were analyzed from rating scales in interviews to answer two research questions: (1) "*Do elementary school students demonstrate SRL metacognitive processes when they use computers and paper-pencil for reading-relating tasks, and what are the key SRL metacognitive processes?*"; and (2): "*Are there differences in SRL metacognitive processes between computer-based and paper-pencil reading tasks across elementary grades*. The rating scales were completed using the adapted Jr. MAI (Sperling, Howard, Miller, & Murphy, 2002). Descriptive statistics for ratings by condition and grade in the regulation of cognition, knowledge of cognition, and motivation constructs are presented in Table 5, while statistical comparisons are shown in Figure 1.

Descriptive Statistics and Correlations

To answer research question 1, whether or not students demonstrated SRL metacognitive practices between conditions, I ran descriptive statistics and correlations. An initial examination of sample means and standard deviations indicated higher use of metacognitive SRL in the paper condition for regulation of cognition constructs, specifically planning, monitoring, and control (Table 5). Likewise, knowledge of cognition constucts, that is declarative and conditional knowledge, appeared to endorse higher use in the paper than in the computer condition. In contrast, the computer condition yielded higher means than the paper condition for evaluation, procedural knowledge, technical skills, self-efficacy, and reading motivation. The dispersity of results (standard deviations) were similar for both conditions, about one standard deviation above the mean.

Table 5

SRL Metacognitive Constructs (mean and SD) in the Computer and Paper Conditions Between Elementary Students in Grades 2-5

			Computer		**Paper**	
Dimension (Range: Min-Max)	**Grade**	***n***	***M***	***SD***	***M***	***SD***
Planning (0-6)	2	8	1.75	0.89	2.63	0.92
	3	13	2.54	1.27	2.75	1.14
	4	16	2.50	1.51	2.38	1.26
	5	11	3.18	1.25	3.00	1.55
	Total	48	2.54	1.34	2.66	1.24
Monitoring (0-4)	2	8	1.50	0.76	1.63	0.92
	3	13	1.92	1.44	2.08	1.38
	4	16	2.00	0.97	2.00	1.16
	5	11	1.91	1.30	2.00	1.00
	Total	48	1.87	1.14	1.96	1.13
Control (0-6)	2	8	2.13	0.99	2.13	0.99
	3	13	1.69	0.95	2.00	1.08
	4	16	2.31	0.95	1.88	0.89
	5	11	2.27	0.91	3.36	1.29
	Total	48	2.10	0.95	2.29	1.18
Evaluation (1-8)	2	8	4.50	1.20	3.63	1.77
	3	13	4.69	2.29	4.46	1.81
	4	16	5.00	1.83	4.00	1.67
	5	11	4.82	1.66	4.82	2.04
	Total	48	4.79	1.80	4.25	1.80

Notes. This table is for descriptive purposes. For statistical comparisons, see Figure 1. *M* represents the mean, and *SD* represents the standard deviation of each associated dimension of a construct. The range represents minimum and maximum total score for each dimension.

Table 5 (continued)

Dimension (Range: Min-Max)	**Grade**	***n***	**Computer** *M*	**Computer** *SD*	**Paper** *M*	**Paper** *SD*
Declarative Knowledge (3-8)	2	8	5.63	1.41	6.13	1.25
	3	13	5.54	1.45	5.31	1.25
	4	16	5.94	1.44	5.94	1.44
	5	11	6.00	1.73	6.27	1.49
	Total	48	5.79	1.47	5.88	1.38
Conditional Knowledge (1-4)	2	8	2.50	0.93	3.13	0.84
	3	13	2.92	0.86	3.08	0.64
	4	16	2.94	0.77	2.81	0.75
	5	11	2.82	0.87	3.27	0.79
	Total	48	2.83	0.83	3.04	0.74
Procedural Knowledge (0-4)	2	8	2.13	1.25	1.75	1.04
	3	13	2.23	1.09	1.83	1.34
	4	16	2.06	1.24	2.06	1.00
	5	11	2.36	1.03	2.27	1.01
	Total	48	2.19	1.12	2.00	1.08
Technical Skills (1-6)	2	8	5.50	0.76	3.50	0.93
	3	13	5.00	0.82	3.00	0.82
	4	16	5.50	0.89	3.31	0.95
	5	11	5.91	0.30	3.36	0.92
	Total	48	5.46	0.80	3.27	0.89
Self-Efficacy (3-6)	2	8	4.88	0.84	4.38	1.06
	3	13	4.85	0.90	4.46	0.97
	4	16	4.63	0.89	4.44	1.03
	5	11	5.18	1.25	4.91	1.22
	Total	48	4.85	0.97	4.54	1.05
Reading Motivation (1-6)	2	8	4.13	1.36	3.75	1.28
	3	13	4.15	1.35	3.92	1.85
	4	16	4.06	1.34	4.31	1.30
	5	11	4.55	1.37	4.36	1.36
	Total	48	4.21	1.32	4.13	1.45

Notes. This table is for descriptive purposes. For statistical comparisons, see Figure 1. *M* represents the mean, and *SD* represents the standard deviation of each associated dimension of a construct. The range represents minimum and maximum total score for each dimension.

Bivariate correlations revealed initial relationships of the combined constructs with each associated dimension (Table 6). Most correlations indicated a moderate magnitude (*r* equal or greater than .29), which was statistically significant (*p* equal or less than .05). Notably, the strongest correlations for “regulation of cognition computer” and “ regulation of cognition paper” were respectively “evaluation computer” ($r = .85$, $p < .01$) and “evaluation paper” ($r = .84$, $p < .01$). The highest correlations for “knowledge of cognition computer” were “procedural knowledge computer” ($r = .85$, $p < .01$), whereas for “knowledge of cognition paper” was “declarative knowledge computer” ($r = .83$, $p < .01$). With computer-associated motivation constructs, “self-efficacy computer” and “reading motivation computer” yielded the strongest correlations ($r = .84$, $p < .01$ and $r = .88$, $p < .01$ respectively). Finally, paper-associated “motivation constructs” revealed a high positive relationship for “self-efficacy paper” ($r = .86$, $p < .01$). A full list of correlations for all itemized dimensions can be found in Appendix H.

Table 6

Bivariate Correlations for SRL Metacognitive Constructs (mean and SD) in the Computer and Paper Conditions for Total Participating Students in Grades 2-5

	1	**2**	**3**	**4**	**5**	**6**
Combined Constructs						
1. Regulation of Cognition Computer	1					
2. Regulation of Cognition Paper	.63**	1				
3. Knowledge of Cognition Computer	.65**	.53**	1			
4. Knowledge of Cognition Paper	.56**	.51**	.63**	1		
5. Motivation Constructs Computer	.58**	.34*	.61**	.67**	1	
6. Motivation Constructs Paper	.52**	.31*	.65**	.69**	.75**	1

Notes. $n = 48$. * $p < .05$; ** $p < .01$.

Table 6 (continued)

	1	2	3	4	5	6
Individual Dimensions – Regulation Computer						
7. Planning Computer	.67**	.57**	.46**	.14	.29*	.29*
8. Monitoring Computer	.72**	.41**	.35*	.43**	.29*	.34*
9. Control Computer	.44**	.12	.34*	.22	.29*	.12
10. Evaluation Computer	.85**	.54**	.57**	.66**	.63**	.57**
Individual Dimensions – Knowledge Computer						
11. Declarative Knowledge Computer	.57**	.39**	.86**	.51**	.59**	.61**
12. Conditional Knowledge Computer	.46**	.43**	.73**	.47**	.29*	.31*
13. Procedural Knowledge Computer	.55**	.52**	.85**	.56**	.56**	.62**
Individual Dimensions – Motivation Computer						
14. Technical Skills Computer	.23	.12	.17	.37*	.58**	.32*
15. Self-Efficacy Computer	.51**	.32*	.59**	.54**	.84**	.61**
16. Reading Motivation Computer	.57**	.33*	.59**	.63**	.88**	.74**
Individual Dimensions – Regulation Paper						
17. Planning Paper	.29	.75**	.32*	.30*	.08	.02
18. Monitoring Paper	.52**	.69**	.36*	.19	.09	.22
19. Control Paper	.32*	.59**	.32*	.43**	.31*	.16
20. Evaluation Paper	.64**	.84**	.51**	.49**	.40**	.36*
Individual Dimensions – Knowledge Paper						
21. Declarative Knowledge Paper	.54**	.43**	.63**	.83**	.61**	.65**
22. Conditional Knowledge Paper	.21	.31*	.41**	.64**	.40**	.40**
23. Procedural Knowledge Paper	.42**	.38**	.32*	.74**	.43**	.40**
Individual Dimensions – Motivation Paper						
24. Technical Skills Paper	.27	-.05	.26	.28	.18	.41**
25. Self-Efficacy Paper	.41**	.28	.66**	.60**	.60**	.86**
26. Reading Motivation Paper	.38**	.33*	.41**	.52**	.67**	.75**

Notes. $n = 48$. * $p < .05$; ** $p < .01$.

To answer research question 2, whether students exhibited differences in their SRL metacognitive practices between grades, I ran mixed model ANOVA. If interaction existed, I followed up with paired sample t-tests to investigate differences between conditions at each grade, as well as univariate ANOVA to examine differences between grades at each condition. Below are the results of these analyses.

Regulation of Cognition Constructs

Overall

Regulation of cognition did not differ between the computer and the paper conditions and there were no differences between grades. These were indicated by non-significant main effects of condition, $F(1, 43) = .01$, $p = .91$, $\eta_p^2 = .00$ and grade, $F(3, 43) = 1.04$, $p = .38$, $\eta_p^2 = .07$, and a non-significant interaction, $F(3, 43) = 1.77$, $p = .17$, $\eta_p^2 = .11$; Figure 1A.

Planning

Planning did not differ between the computer and the paper conditions and there were no differences between grades. These were indicated by non-significant main effects of condition, $F(1, 43) = .92$, $p = .34$, $\eta_p^2 = .02$ and grade, $F(3, 43) = 1.29$, $p = .29$, $\eta_p^2 = .08$, and a non-significant interaction, $F(3, 43) = 1.11$, $p = .35$, $\eta_p^2 = .07$; Figure 1B.

Monitoring

Monitoring did not differ between conditions or grades as indicated by non-significant main effects of condition, $F(1, 44) = .23$, $p = .63$, $\eta_p^2 = .005$ and grade, $F(3, 44) = 0.44$, $p = .73$, $\eta_p^2 = .03$, and a non-significant interaction, $F(3, 44) = 0.04$, $p = .99$, $\eta_p^2 = .003$; Figure 1C.

Control

The grade-associated responses of control differed between conditions, leading to higher control in the paper than the computer condition at fifth grade. Control demonstrated a significant condition-by-grade interaction in mixed-model ANOVA, $F(3, 44) = 4.14$, $p = .011$,

$\eta_p^2 = .22$; Figure 1D. The main effect of condition was not significant, $F(3, 44) = 2.06$, $p = .16$, $\eta_p^2 = .05$, but the main effect of grade was significant, $F(3, 44) = 2.93$, $p = .04$, $\eta_p^2 = .17$. Paired sample *t*-tests indicated that control was higher in the paper than the computer reading task for fifth grade students only $t(10) = -2.96$, $p = .014$; there were no significant differences for other grades. In follow-up one-way ANOVA, the effect of grade was non-significant for the computer reading task, $F(3, 44) = 1.20$, $p = .32$, $\eta_p^2 = .08$. The effect of grade, however, was significant for the paper reading task, $F(3, 44) = 4.99$, $p = .005$, $\eta_p^2 = .25$. Students in fifth grade demonstrated higher control during the paper task than students in the third and fourth grades ($p = .018$ and $p = .005$, respectively); there were no differences between other grades.

Evaluation

Students across grades had higher scores for evaluation during the computer than the paper condition, as demonstrated by a significant main effect of condition, $F(1, 44) = 5.54$, $p = .02$, $\eta_p^2 = .11$ and a non-significant interaction, $F(3, 44) = 1.29$, $p = .29$, $\eta_p^2 = .08$; Figure 1E. The main effect of grade was not significant $F(3, 44) = 0.32$, $p = .81$, $\eta_p^2 = .02$.

Knowledge of Cognition Constructs

Overall

Knowledge of cognition did not differ between the computer and the paper conditions and there were no differences between grades. These were indicated by non-significant main effects of condition, $F(1, 43) = .29$, $p = .59$, $\eta_p^2 = .01$ and grade, $F(3, 43) = .36$, $p = .78$, $\eta_p^2 = .03$, and a non-significant interaction, $F(3, 43) = .71$, $p = .55$, $\eta_p^2 = .05$; Figure 2F.

Declarative Knowledge

The mixed-model ANOVA showed that declarative knowledge did not differ between conditions or grades. There were non-significant main effects of condition, $F(1, 44) = 1.01$, $p = .32$, $\eta_p^2 = .02$, and grade, $F(3, 44) = 0.81$, $p = .49$, $\eta_p^2 = .05$, and a non-significant interaction, $F(3, 44) = 0.89$, $p = .45$, $\eta_p^2 = .06$; Figure 2G.

Conditional Knowledge

Conditional knowledge was higher in the paper than the computer condition. This was demonstrated by a significant main effect of condition, $F(1, 44) = 5.23$, $p = .03$, $\eta_p^2 = .11$. There were not differences between grades as the main effect of grade was not significant, $F(3, 44) = 0.35$, $p = .79$, $\eta_p^2 = .02$, and there was a non-significant interaction, $F(3, 44) = 1.91$, $p = .14$, $\eta_p^2 = .12$; Figure 2H.

Procedural Knowledge

Procedural knowledge did not differ between conditions and between grades. The mixed-model ANOVA yielded non-significant main effects of condition, $F(1, 43) = 1.16$, $p = .29$, $\eta_p^2 = .03$, and grade, $F(3, 43) = 0.32$, $p = .81$, $\eta_p^2 = .02$. and a non-significant interaction, $F(3, 43) = 0.28$, $p = .84$, $\eta_p^2 = .02$; Figure 2I.

Other Motivation Constructs

Technical Skills

Technical skills did not differ between conditions and between grades. There were non-significant main effects of condition, $F(1, 44) = 1.28$, $p = .26$, $\eta_p^2 = .03$, and grade, $F(3, 44) = 2.31$, $p = .09$, $\eta_p^2 = .14$, and a non-significant interaction, $F(3, 44) = 0.36$, $p = .78$, $\eta_p^2 = .02$; Figure 3J.

Self-Efficacy

Self-efficacy did not differ between conditions and between grades as indicated by non-significant main effects of condition, $F(1, 44) = 3.61$, $p = .06$, $\eta_p^2 = .08$. and grade, $F(3, 44) = 1.20$, $p = .32$, $\eta_p^2 = .08$, and a non-significant interaction, $F(3, 44) = 0.33$, $p = .80$, $\eta_p^2 = .02$; Figure 3K.

Reading Motivation

Reading Motivation did not differ between the computer and the paper conditions and there were no differences between grades. These were indicated by non-significant main effects of condition, $F(1, 44) = .88$, $p = .35$, $\eta_p^2 = .02$ and grade, $F(3, 44) = .29$, $p = .83$, $\eta_p^2 = .02$, and a non-significant interaction, $F(3, 44) = 1.02$, $p = .39$, $\eta_p^2 = .07$; Figure 3L.

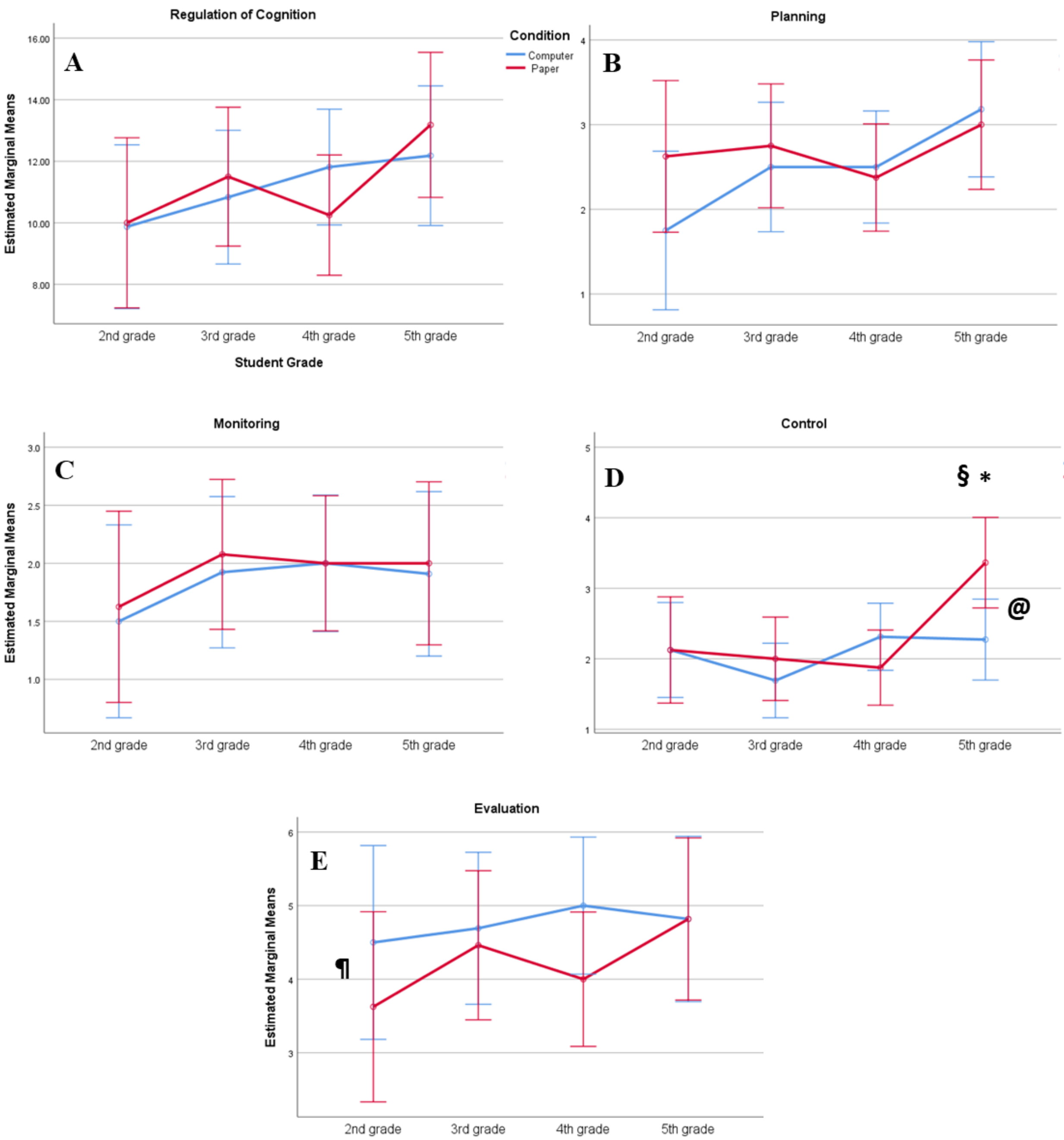

Figure 1. *Regulation of Cognition Constructs During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

Notes. The inserted symbols in some charts indicate: ¶ $p < .05$ for main effect of condition in mixed-model ANOVA; @ $p < .05$ for main effect of grade in mixed-model ANOVA; * $p = .01$ in paired-samples *t*-tests following significant interaction in mixed-model ANOVA; § Significantly different ($p \leq .04$) from third and fourth grade in Bonferroni tests following one-way ANOVA for the paper reading condition across grades. Lines represent means for each condition and error bars represent 95% confidence intervals.

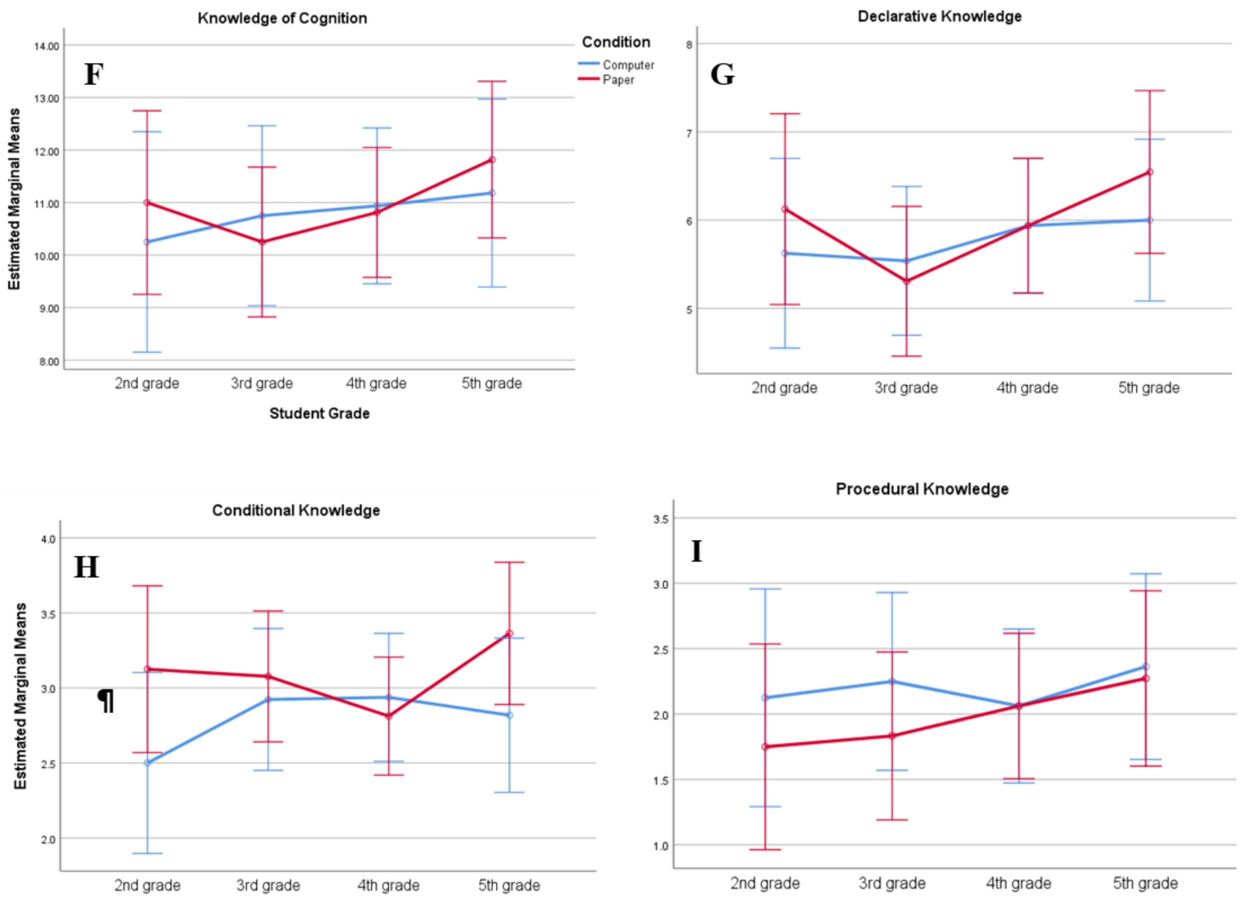

Figure 2. *Knowledge of Cognition Constructs During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

Notes. The inserted symbols in some charts indicate: ¶ $p < .05$ for main effect of condition in mixed-model ANOVA. Lines represent means for each condition and error bars represent 95% confidence intervals.

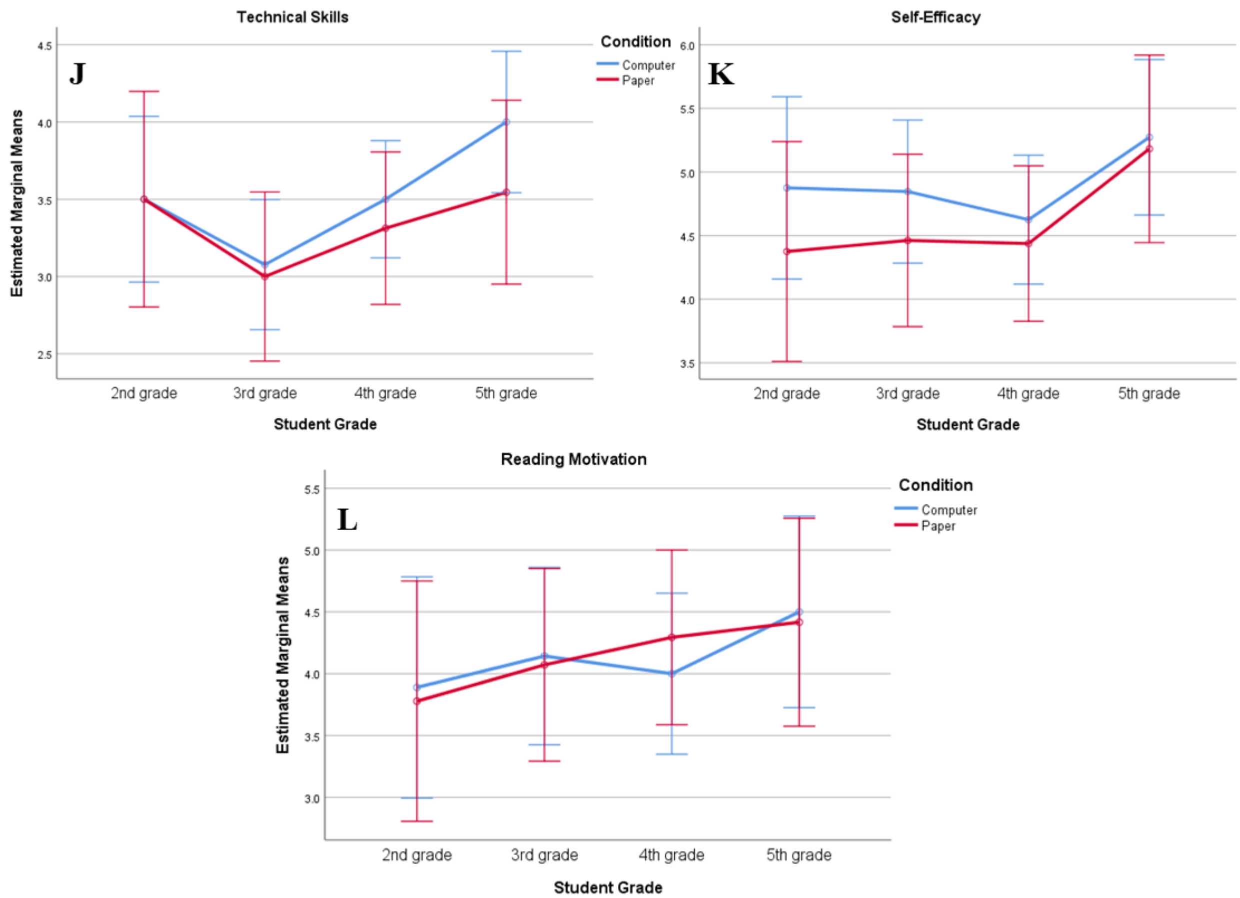

Figure 3. *Motivation Constructs During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

Notes. Lines represent means for each condition and error bars represent 95% confidence intervals.

Summary of Quantitative Results

Overall, there were no differences between grades or between the paper and computer conditions for most regulation of cognition constructs except for control and evaluation practices. Students in fifth grade demonstrated higher levels of control in the paper than in the computer condition and their control during the paper condition was higher than younger grades. Students across grades showed higher levels of evaluation in the computer than in the paper condition. Among knowledge of cognition constructs, conditional knowledge was higher in the paper than in the computer reading assignment across grades; there were no other differences between groups or grades in knowledge of cognition constructs. There were no differences between conditions or grades in declarative and procedural knowledge, technical skills, and self-efficacy. These analyses suggest that control and evaluation strategies, and conditional knowledge processes tend to be dependent on the medium that facilitates the reading task. No differences between conditions and between grades seem to emerge for any other SRL metacognitive dimension without prompting.

Qualitative Findings

Overview

Qualitative data were analyzed to answer two research questions: (1) "*Do elementary school students demonstrate SRL metacognitive processes when they use computers and paper-pencil for reading-relating tasks, and what are the key SRL metacognitive processes?*"; and (2) "*How are differences in SRL metacognitive processes between computer-based and paper-pencil reading tasks across elementary grades exhibited?*" Qualitative data consisted of observations and interviews. Observations provided firsthand experiences with each student's behavior in computer and paper reading tasks; memos and reflections from the researchers enriched the observational findings. Interviews provided self-reported accounts of SRL metacognitive skills during computer and paper reading tasks, while prompts, and retrospective and follow-up questions to students expanded the interview findings. Frequency data for the constructs of interest are shown in Appendix C.

Regulation of Cognition Constructs

Planning

Planning refers to organizational thinking and preparatory actions to fulfill a learning goal (Corno, 1994; Greene, et al. 2010). Generally, in our study we did not observe students perform any planning to complete a reading task. The absence of a clear planning process may imply a lack of instruction in that SRL area or lack of understanding of use of this strategy. However, there were hints of some form of planning process across grades, evidenced more in the paper than in the computer condition.

Students exhibited certain actions that could be interpreted as signs of planning, such as reading an entire passage first and then responding to questions, relying on teacher assistance or on computer character narration. To this end, we observed that second and third grade students first read a passage in its entirety and looked for word definitions, and then responded to questions. Yet, when asked, second graders did not explicitly mention performing any planning before or during the completion of a computer reading assignment other than "concentrating." Meanwhile, some students in Grades 3 and 4 pointed the cursor to a word to direct eye-text movement. When asked, third graders intuitively expressed using the process of elimination as a response plan but they could not explain why. Furthermore, statements from fourth grade students suggested a reliance on teacher instruction and an emphasis on specific vocabulary words as planning tactics. Only a few students in fourth grade created annotations in a separate sheet for computer reading assignments. Remarkably, students in third and fourth grades perceived annotations as a form of "cheating" because of not using their "own brain" but an external aid. Fifth grade students exhibited no planning practices that we could observe, but relied on computer characters for story narration or question citation. Even though this tactic resulted in responding without reading, fifth graders claimed that computer narration helped them comprehend word definitions and pronunciation and cross-check with their own thinking process:

> The text helps and the way that the computer character speak also helps me think about the way I say it [and] the way they say it. And I kind of combine it together and I know how to say it. For the “Write” portion, I usually answer the question and then I know that since I've answered the question, let him [computer character] know what I'm talking about. And then I just use the rest of my own words. (Girl, fifth grade)

Students across grades demonstrated some planning processes during the paper-based task by reading a passage in its entirety before responding to questions or by looking for context clues. In this respect, we observed some second grade students finger- or pencil-pointing while reading, or even numbering verses when the reading assignment was a poem. These practices presumably supported directional movement and student voice-print match, which are critical in transitional readers. Students in third and fourth grade, who are assumingly more fluent readers than younger students, approached paper reading in a structural way: some first checked all text boxes and passage in the worksheet, while others looked at all questions first and then proceeded to answering them. In addition, third graders mentioned tangible elements for planning their reading in print, e.g., looking at title or identifying context clues, and then “circling the best response”, or “eliminating at least half of those [responses] that might be wrong.” Most students in third grade did not make annotations. Fourth graders appeared influenced by the genre of a reading assignment and some briefly paused to integrate previous learning experiences before responding to questions. Contrary to computer reading, some fourth graders made annotations as self-reminders for paper reading, especially for reading texts perceived as "hard." This implies a shift in focus from "learning to read" in lower grades to "reading to learn" in fourth grade for different content areas (MacWhinney, 2015). Finally, fifth grade students viewed a reading passage in its entirety, pondered, and then started answering questions. They notably perceived annotations as an "off-track" activity that contributed to lose focus and did not practice it.

Similarities in planning processes across conditions and grades included: (a) directional movements either using the computer cursor or pointing a pencil to aid focus and completion of the reading task; and (b) a structural approach to reading. However, we identified the following variations in planning between conditions or grades: (a) fourth grade students integrated prior knowledge for completion more in the paper than in the computer condition; (b) third grade students used more context clues in the paper than in the computer condition; (c) third grade students applied process of elimination in both conditions; (d) few fourth grade students made annotations in both conditions; and (e) fifth grade students listened to computer narration.

Monitoring

Monitoring is the cognitive reaction that drives learning goals while regulating thought and behavior (Brown, 1977). Generally, students demonstrated some form of monitoring in both the computer and the paper task. Monitoring was prior knowledge-based in grades 2 and 3, but task-based in grades 4 and 5. This pattern may indicate a critical shift in monitoring skills; as students advance in grades, monitoring may no longer reflect acquisition of literacy skills but knowledge transfer to understand the content of a reading task (Hattan & Dinsmore, 2019; Snow et al., 1998).

During the computer task, second grade students asked questions to themselves and repeated difficult words as ways to crystallize understanding. Another method was to ask the researcher questions about a segment of a reading assignment ("writing" portion), or about the meaning or spelling of a word. Emotional associations were also observed when a few second-grade students asked, "is the reading hard?" or "is the reading for a grade?" Additional monitoring practices included checking answers to ensure accuracy, but this was mostly reported by students in upper grades. For third graders, rechecking and rereading resulted from a bad grade in a test, which prompted some students to rely on computer character narration because it "helps to understand and get it right." Yet, some fifth graders perceived computer character narration as confusing because it contradicted their prior knowledge. Those students talked to themselves to check for previously learned elements in the text and then kept on reading to understand. Some third-grade students first looked for text clues by highlighting relevant portions with the mouse, or by reviewing all selected responses before proceeding to the next screen. For students in fourth grade, asking clarifying questions was either in response to the writing portion of a reading assignment or their overall performance in a computer test. Computer feedback served as a common monitoring practice that resulted in a revised response for fourth and fifth graders alike. For example:

> "If I can't remember what I answered wrong, the program tells me when I answer a question wrong. So, when I don't understand it, I might read it a couple of times. And then if I can, I might see if the computer will read it, just to clarify what it is" (girl, fourth grade).

As for the computer condition, students either asked themselves or asked another person questions during the paper-based reading task. Asking questions was a strategy documented in both observations and interviews. Asking oneself questions evolved in the following manner:

As a student read multiple choice options, he said "maybe" for the correct option. In the case of open-ended questions, the student repeated the phrase "which item supports the point" before he answered. The student tilted his head up and whispered, "what was I thinking about that?" After the student read options again, he posed a question by asking "so what was the question again?" [Researcher observation notes for a boy in second grade]

The questions that students asked focused on the meaning and pronunciation of challenging words. Emotional concern was observed when students in lower grades asked about whether the reading assignment was "hard" or "for a grade." For students in grades 2 and 3, response verification happened upon teacher review. Additionally, looking at context clues for response verification was a common practice among students in grades 3 and 4. However, some fourth graders said that "second-guessing" acted to their disadvantage and to erroneous responses "because a lot of times when I do that, I get it wrong when I had the right answer" (boy, fourth grade). Furthermore, the formality of "how to do things" seemed to occupy the majority of fourth and fifth grade students who asked about open-ended question completion, reading aloud, recording evidence from the passage, or graphical representation for meaning.

There were some variations between conditions and grades in monitoring practices. Fourth and fifth grade students used computer-generated feedback to a greater extent than students in other grades. Third grade students used informational clues more in the paper than in the computer condition. However, students across grades had similarities in monitoring learning during both conditions such as asking questions, rechecking answers, and showing affective states.

Sounding Out. An emerged sub-theme of monitoring was the idea of sounding out, evidenced more in the paper than in the computer condition. According to students, "sounding out" meant piecing together a word into its syllables. In the computer task, sometimes "sounding out" occurred with computer-generated feedback. For second and third grade students, "sounding words out" was a way to understand ambiguous reading elements. This understanding likely resulted in completing the assignment correctly. Fourth grade students seemed to rely on the computer for pronunciation and meaning of unknown words: "if it's important, I'll click on [word] and [computer program] will have a speech thing. I'll see what it is and the definition of the word" (boy, fourth grade). On the other hand, some fifth graders stated that they had tried "sounding out" but this practice did not improve their comprehension.

In the paper task, students retrospectively mentioned that "sounding it out" helped them understand unknown or unclear words. This practice was recorded in second, third, and fourth grade students. However, "sounding out" a word did not yield the desired result among second graders which is in agreement with previous literature showing that second grade students may still be in the process of understanding language conventions (Paris & Flukes, 2005). Conversely, for third grade students, sounding out had an opposite effect: it helped them "figure out what the answer is" and contributed to close reading practices (e.g., rereading, reflecting) and heightened self-efficacy. Fourth grade students gained confidence in paper reading by "try(ing) to spell [a word] out by a sound" (boy, fourth grade). Some fourth graders also mentioned that examining the parts of a word provided enough understanding about the content of the paper reading assignment: “I look at the beginning of the word and what that means, and then I look at the end of the word, and then I figure out what the word means” (boy, fourth grade). Other fourth graders mentioned that “sounding out” was a multi-step process where they broke a word in its parts: “I'll cover up part of the words and say ‘participation.’ I'll cover up ‘icipation’ and I say, ‘I know that word is ‘part’ and then I'll figure out the next part and the next part” (girl, fourth grade).

Control

Metacognitive SRL involves active control and corrective actions, including strategies for learning: organization of ideas, close reading, reading aloud, and retrying (Flavell, 1979). Generally, students across grades were keener in retrying and organizing while on computer reading than on paper reading, but they performed close reading mostly in paper reading assignments. Reading aloud was barely evidenced in any of the two conditions, whereas the use of visual cues facilitated retrying in both conditions.

Students demonstrated some control processes during computer-based reading. Organizing information in charts seemed easy for students in the computer condition. Fourth and fifth grade students acknowledged the fact that creating pictures or diagrams left a mental trace that aided in remembering information. Yet, when asked, students across grades reported that tables/charts did not constitute ways to understand a computer reading assignment. Tables and diagrams may contribute to memory skills but the ability to comprehend was not reported, a finding that contradicts previous literature (Davis, 1944; Fry, 1983). Further, close reading habits were not documented in computer condition, which may suggest a negative influence of computer reading on SRL skills (Stoop et al., 2013). However, students in Grades 2 and 3 stated that information on sidebars and context clues assisted them with deciphering important information. Likewise, students in Grades 4 and 5 used information cues and "read it" buttons to review and understand a reading passage on the computer. This proved for some students an effective way to "almost always get the questions right." Reading aloud was displayed in a surprising way in the computer condition – sourced from the computer instead from the student. More than half of second graders relied on computer characters narrating a paragraph or citing questions and response options, but that contributed to eye regression – the direction of eye movement opposite to the reading stimulus (Booth & Weger, 2013).

As for the computer condition, students demonstrated some control processes for paper-based tasks. Table/chart creation was more challenging in the paper condition in lower grade students as many of them did not understand how to do it, resulting in skipping that part of a reading assignment. Students in fifth grade only were successful in creating an organizational chart but almost everyone left it incomplete because of time restrictions. In the paper condition, close reading called for surface-level strategies, like underlining or circling; this was mostly evident among second graders. Third graders tended to pause and ponder as they gradually completed the writing portion of a paper reading assignment. Conversely, fourth graders read titles, bold words, and hint boxes. Response elimination (i.e., crossing out response choices and circling the correct or best response) was a prominent reading comprehension control strategy for fifth grade students. Reading aloud was hardly evidenced. Only a few students whispered or moved their lips while they read in the paper condition. Students in grades 2 and 3 claimed that they did not want "to give away" their answers and attested that "reading in my head is more helpful" and this way "I would not interrupt the class." Other fourth graders seemed to associate reading aloud with an emotional state because "if I can't do it, it makes me more stressed out, and when I can read out loud, I can understand it while I have to process it in my head reading it." Voicing silently words was observed in some third, fourth, and fifth graders when incorrect selections led to retrying. Subvocalization – the movement of the mouth when reading silently – may characterize less fluent readers but it aids reading comprehension (Bruinsma, 1980).

In both the computer and the paper condition, visual elements seemed to mediate students' review and retry. Visual elements acted as comprehension triggers for students to check learning and proceed with a strategy that typically included checkmarks, smiley faces, and praise from animated characters in the computer condition, as well as bold words and informational text boxes in the paper condition. The integration of multimedia and verbal cues seemed to support a mental model that aided comprehension and allowed students to decode meaning, an important strategy in reading comprehension (Woolley, 2010).

In both conditions, students stated that schematic representation of content was not a skill taught; this finding was consistent in grades 2, 3, and 4. Most younger students lacked the ability of showing relationships, identifying patterns, and establishing connections in text, a skill which older students presumably mastered (Meyer, 1975). Nevertheless, computer embedded charts facilitated student learning because they made content easier to understand and remember, but this occurred at the expense of students creating charts or tables on their own (Wexler, 2019). Students did not read aloud in the computer condition consistently across grades; however, students in grades 3, 4, and 5 used their inner voices in the paper condition.

Distractions. An emerged sub-theme of control was the idea of distractions which were more evident during computer than paper reading. Students reported that completing computer reading tasks decreased concentration. Distractions were common in third and fourth graders who reported that "friends [being] loud," "students kicking [feet]," "a boring passage," and "people hollering" were potential distractions. Students perceived "distractions" as nuisances contributing to low performance and negative consequences at home. However, older students perceived “distractions” as advantageous because they triggered them to seek assistance from teachers.

A form of distraction was eye regression – defined by Squire et al. (1998) as the backward movement of the eye when reading. In this study, eye regression represented eye movement away from the text which seemed to interrupt SRL practices and independent learning. Eye regression was more evident in older than younger students. Specifically, fourth graders seemed to divert their attention from the computer screen and look elsewhere, or fidgeted with irrelevant objects (e.g., own glasses, headphone cord). Likewise, eye regression in fifth grade students resulted in performing no SRL practices and in responding without reading. Notably, some third-grade students crossed hands or held their face in boredom in response to lengthy passages and difficult vocabulary during the computer task.

Evaluation

Evaluation involves the performance mechanism by which a learner assesses if the desired goals have been met (Manlove et al., 2007; Zimmerman, 1989). Overall, students across grades used a similar evaluation process to assess their performance in the computer and paper condition. This was their progress score which was instantaneously reported in computer reading but delayed in paper reading.

A form of evaluation occurred when students completed computer-based reading assignments – students used embedded features to evaluate their performance; however, there were small variations between grades. Students relied on interactive multimedia to check the accuracy of a response. Interactive multimedia varied and included “green highlighted text” or “confetti throws” for correct responses, green “DONE” signs for completed responses. Furthermore, praise prompts such as “beautiful,” “you got it,” “good job,” or “nice one” enabled students to evaluate their progress in a computer reading assignment. However, the computer program did not allow students to go back to previous screens if they had rethought a response and wanted to correct it. Most third graders evaluated their reading performance on a computer reading assignment using their progress score: “because one time, I didn’t check my answer, I did mostly move on to the question, but then I got a ‘71’ because I didn’t go back and now I’m starting to go back and see” (boy, third grade). Most fourth and fifth grade students used computer feedback as an evaluation tool when reviewing a response. However, a few fourth graders used “trial and error” as an evaluation process. These students clicked on different response options to hear how these sounded in a sentence and then made a final choice.

During paper reading assignments, students evaluated their performance by going back to the text. Repetitive going back (up to eight times on some occasions) was evident in the writing portion of a paper assignment, especially for students in grades 3 and higher. Third grade students stated that new information necessitated to “look at words around it” for gaining clarity. Fifth graders seemed to rely more on memory skills because they checked back less often than students in earlier grades. There were no instant evaluation prompts in paper-based reading. Students across grades reported that they did not always know their progress on a paper reading assignment, unless the teacher graded it instantly and marked it with “smiley faces” for successful completion.

We recorded two major differences in evaluation between computer- and paper-based reading assignments. One difference was the nature of evaluative feedback. During computer-based reading, students received continuous feedback and an instantaneous score. During paper-based reading, students reported that teacher feedback and score were delayed. The faster speed of evaluation seemed to provide more opportunities for corrective actions in computer- than paper-based reading (Mareye & Makram, 2019). The other difference was that students went back to the text to review and evaluate their performance more often in the paper than the computer task, which suggests a persistence in recalling information during paper reading (Singer & Alexander, 2017).

Knowledge of Cognition Constructs

Declarative Knowledge

Declarative knowledge is the ability to recall facts and events and it requires conscious effort and explicit memory (Boekaerts, 1997). Overall, students demonstrated awareness of their thought process and actions during both the paper and the computer reading task. Constant comparison between text and questions, teacher guidance, and hierarchical processes acted in favor of successful completion.

Students across grades indicated awareness and conscious effort in understanding content and questions of computer-based reading. Second and third grade students acknowledged difficulty with unknown words. When that happened, second graders found reading a passage alongside questions helpful, whereas third graders used the process of association to comprehend the meaning of a word. Specifically, third grade students "keep reading it to see if it talks about something like it, but isn't the same word, [but] like the one that I can understand" (boy, third grade), or "read around it to see what it means" (boy, third grade). To alleviate frustration with a computer reading assignment, second, third, and fourth grade students applied additional strategies including turning to teachers for assistance and guidance, or setting expectations. Third graders mentioned that time restrictions made them repeat computer reading assignments. However, students reported that, with multiple attempts, they could not remember previously entered information: “not able to finish it all the time and usually have to go back and do it. And then I can’t remember what I’ve done already” (boy, third grade). Fourth grade students mentioned that interest in a topic triggered “writing down notes” which helped with remembering content of a computer reading assignment. For fifth grade students, understanding a computer reading assignment was associated with a hierarchy of steps: first read “slowly and calmly”, then listen to the audio, next find important words and surrounding clues for definitions (girl, fifth grade). Furthermore, students proficient in reading (“best subject;” girl, fifth grade) easily understood assignments delivered in computer.

Students in most grades acknowledged a conscious effort that emanated from teacher feedback when engaging with paper-based reading. Second grade students reported that sometimes teachers encouraged them to “look again at the passage.” Teacher encouragement and guidance was noted by fourth grade students, as well: “our teacher always tells us to cross out the dialogue in the passage after we read it. I think like it might be the main idea that supports the main idea” (boy, fourth grade). Noteworthy was an emotional discomfort reported by students in grades 2 and 4. Second-graders stated that teachers emphasized paper reading assignments as a step to pass the state reading gate test in third grade[2]. This information urged second-graders to retry paper-based reading assignments, even though state assessments

[2] The third grade reading gate test, official called 3rd Grade Mississippi Assessment Program English Language Arts (MAP-ELA), is a summative test to determine competency in reading and is required for promotion to fourth grade (MDE, 2016).

sometimes worried these students ("what if I fail".) Fourth grade students reported that teachers helped them overcome stress from completing paper reading assignments. Conversely, third-graders stated that understanding a paper reading assignment required repetition: "reading it over and over again until realize the right answer" (boy, third grade). Some third-grade students claimed that they learned more from a "challenging" reading topic because they could better remember it. Students acknowledged that their answers were wrong when "misreading a passage," but rechecking helped to get them right. As in the computer task, fifth grade students seemed to use a methodology for understanding a paper reading assignment: "think about the question and what need to answer" (girl, fifth grade). Students claimed that even though teachers did not tell them what to do in a paper reading assignment, the expectation was to complete it thoroughly and clearly.

The most notable difference between the paper and computer conditions was text interest. Across grades, most students distinctly stated that their understanding of and performance on a reading assignment depended primarily on the reading topic (Hacker et al., 2009). Interest in a topic made students focused and engaged particularly in the computer condition. Conversely, disinterest in a topic contributed to less clarity and rereading in the paper condition. The concept of text interest insinuated the use of reading comprehension strategies; for example, looking for context clues. Text interest presumably increased cognitive engagement and motivated students to read and complete a paper reading assignment (Koriat, 2012; Robson, 2012). Second and fourth grade students shared feelings of emotional stress sourced from paper-based reading. Opportunities to master reading and acquire skills in reading comprehension are important at these grade levels as students transition from a "learning to read" to a "reading to learn" mode (Q.-S. Chen, 2009; Schreiber, 2005).

Conditional Knowledge

Conditional knowledge refers to knowledge about when and why to learn (J. Flavell H., 1979; Schraw, 2006). Most students across grades did not explicitly state any self-learning or transfer of knowledge strategies when completing computer or paper reading assignments. However, performance appeared to trigger successful completion across grades, while the influence of prior knowledge varied among grades.

Concentrating was a method some second and fourth grade students mentioned when completing computer-based reading. Second graders could not articulate any learning effects from applying it; however, fourth graders associated concentration with better performance. For fourth grade students, maintaining high grades or "trying to get the highest score" (girl, fourth grade) triggered comprehension of computer reading assignments. Conversely, third grade students tried to "repeat new information in their mind" as a way to remember it (girl, third grade) and acknowledged that previous familiarity with a reading topic helped comprehension. Students believed that teacher instruction helped them with learning best and reinforced using their memory skills. Fifth grade students expressed similar thoughts with students in earlier grades. For fifth graders, performance seemed to be a main factor to learn, achieve a personal best, and "benefit all the way" (boy and girl, fifth grade) in the computer task. Additional components that contributed to successful completion of a computer reading assignment were text familiarity and prior knowledge.

Students in second, third, and fifth grade associated text familiarity with successful performance in paper-based tasks. Furthermore, some gifted[3] second graders perceived

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[3] Citation from the local school district: "The local school district offers two programs for gifted and talented students: PEAK and VIVA. Program for the Enrichment of Academic Knowledge (PEAK) is designed for students

maintaining good grades as an incentive for to stay in a special class. Score performance seemed to fuel learning for fourth graders. Nevertheless, familiarity with a reading topic acted against comprehension for some of them. For fifth grade students, background knowledge provided a feeling of comfort and contributed to answering questions correctly. Additionally, fifth grade students appeared to draw upon feelings of "pretend" enjoyment to tackle a paper reading assignment. As a fifth grade girl stated:

> "You need to push it 'cause it's going to be over at some point." I say that when it's not quite that fun, but sometimes when it's fun, I'm saying that "I can answer the questions and that it's fun" so I can deal with it.

Notably, students claimed that prior knowledge contributed to achieving a learning goal in paper reading. Students in third and fifth grade associated background knowledge with reading comprehension and performance, but students in fourth grade did not. Prior knowledge seemed to positively affect learning in the computer condition but only for fifth grade students. Furthermore, students in third grade said that they benefited mostly from their teacher's instruction while completing computer-based reading assignments.

Procedural Knowledge

Procedural knowledge refers to knowledge of applying certain procedures and learning strategies to achieve learning goals and it incorporates implicit memory (Winne, 1995, 2011). Students' statements in the computer condition revealed that rechecking, rereading, or response

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who meet state guidelines for the Intellectually Gifted and is taught in grades 2-6. Verbal Innovations and Visual Arts (VIVA) is designed for students who meet state guidelines for artistically gifted and is taught in grades 4-5." Retrieved on October 10, 2021 from https://www.starkvillesd.com/departments/student-support-services/gifted-talented-education elimination were strategies most likely influenced by performance. In the paper condition, strategies to comprehend a reading assignment affected performance but comprehension was more teacher-driven than in the computer condition.

Students in lower elementary grades said that failure and fear contributed to successful completion of computer reading. Second graders mentioned that “if we fail three or four times, then they (teachers) put it (reading assignment) back to us to get to it better” (girl, second grade), and “be scared is the best way. It helps me know, then I should do good” (boy, second grade). Moreover, third graders spoke about disciplinary actions from family “ just do your best or there are going to be consequences, out of my range” (boy, third grade). Notably, the concept of failure also emerged among fifth graders when they mentioned that they did not score well in a computer reading assignment and had to retake it. Students in third and fourth grade practiced rereading and looking for informational meaning of difficult text. In particular, students read a paper passage “slowly” and repetitively (“read back three times” boy, third grade) or use “a glossary, if I don’t know the meaning” (girl, third grade). If they could not comprehend meaning, students eventually turned to the classroom teacher for explanations to unknown words or new concepts. Some fourth grade students recognized certain limitations of computer reading assignments when they mentioned that computers did not provide the flexibility of making annotations as paper reading assignments did. That aspect restrained some fourth graders from understanding the material because they perceived annotations as a way to comprehend better. Fourth graders pinpointed that teachers did not provide paper to write notes during computer reading assignments and attributed this to teachers perceiving annotations as “cheating because you already know the answer [from the side note], so then you can just put the right answers” (girl, fourth grade). As for students in lower grades, fifth graders mentioned that informational buttons and rechecking helped them understand computer reading assignments. However, familiarity with a topic did not always enable use of strategies for completing computer-based reading. Students attributed that to variation in the ways reading genres were presented.

In paper-based reading, second grade students mentioned that the teacher “tells us what to do” (girl, second grade) for readings that had new concepts and information, or for readings that involved testing. Third graders recognized that rereading a passage helped them to “make sure the answer is right” (boy, third grade) and prevented them from getting a lower score in a paper reading assignment. Some fourth graders reported that “the title, looking around the word for clues, or reading the first part of a question” (boy and girl, fourth grade) helped to tackle a paper reading assignment. Students in fourth grade also mentioned using annotations to complete paper reading assignments: “just write on a piece of paper, important things, super hard words, words to remember. I write the word and then I write the definition” (girl, fourth grade). Other fourth graders mentioned an alternative strategy learned in Kindergarten: the five “Ws” (i.e., when, why, who, what, and where), asking for example, “where is the studying, who are the characters, why is the problem happening?” (boy, fourth grade). Fifth grade students reported using low-utility methods to comprehend main ideas of a reading topic presented on paper; these methods ranged from circling important words, marking sentences to rethink, reading the paragraphs, or crossing out irrelevant responses.

Students across grades provided more salient responses in the paper than in the computer condition. Students seemed to follow SRL processes, such as retaking an assignment, or checking for context clues. Students in second grade relied more on teacher assistance than students in upper grades and more so during the computer-based task (Paris & Flukes, 2005). More students in second grade than other grades associated teacher guidance with successful completion of paper-based reading assignments. Furthermore, more students in fourth and fifth than other grades reported that, during paper reading, they used annotations and an array of low-utility practices, as previously established by the National Reading Panel (2000). Finally, students expressed affective states more often in computer- than paper-based reading.

Other Motivation Constructs

Technical Skills

Technical skills include awareness and knowledge of navigating and completing reading tasks (Brown & DeLoache, 1977). Students exhibited skill with both computer- and paper-based reading tasks. Younger students in second, third, and fourth grade relied on teacher assistance for overcoming technical difficulties, whereas fifth graders oriented themselves effectively.

Students across grades demonstrated ease with navigating a computer-based reading assignment and knowledge with operating the computer mouse. Computer use was a behavior learned before grade school but with slight variations. Some second graders mentioned that they learned how to use a computer at home through their parents' devices and before entering kindergarten. Third graders learned computers at kindergarten, while fifth graders stated first grade as onset of engagement with computers. Third and fourth grade students seemed more adept than students in other grades at using the mouse by holding it with half of their palm or directing it with one finger. For some fourth graders, the computer seemed unfamiliar as for a student who hovered the mouse over text aimlessly and another student who had trouble using the computer program. Younger students mentioned certain difficulties with computer operation which they overcame by requesting and receiving assistance from teachers.

In the paper version of a reading assignment, students across grades knew how to orient themselves and were able to start and finish successfully. For second and third graders, teacher guidance was typical when completing paper reading assignments. Also, the numbering of questions and side indentations helped students with understanding where to start and finish.

Students across grades were able to complete a reading assignment both in the paper and computer conditions. Differences in technical skills were purely system-driven. Computer- and paper-based reading assignments have separate operational foundations but the common goal of both is to complete a reading task (Kunz et al., 1992).

Self-Efficacy

Self-efficacy is the belief in one's ability to successfully realize their goals and contributes to self-confidence (Bandura, 1977, 1989). Generally, students demonstrated self-efficacious behavior when completing computer- and paper-based reading assignments, which generated behavioral and cognitive variations across grades. In the computer condition, students demonstrated decreased reading motivation and comprehension outcomes, whereas in the paper condition students applied more SRL practices than in the computer condition.

Students demonstrated some level of self-efficacy when they completed computer-based reading tasks. This sourced from the computer medium itself and students' own reading ability. The ability of second and third grade students to respond was mediated by first listening to the computer character narration. Even though third graders made spelling mistakes or had to retake a reading assignment because of a low score at first attempt, they believed that computer animated characters guided them and provided a sense of confidence in completing a computer-based reading task. Remarkably, only one third grade student relied on their own reading ability.

Reading along with computer characters was challenging for second graders who mentioned experiencing difficulty in timing their own reading with that of computer characters, resulting in decreased comprehension. Third graders appeared confident in understanding the content of a reading assignment, correctly identifying word synonyms, or matching words with images. A few third-grade students attributed their confidence to the fact that their families "pushed [them] to read six grade level books." Some fourth-grade students knew that they first had to read the passage, highlight the text, and select the correct response. Fourth grade students reported that the questions themselves helped their understanding and increased their self-efficacy when completing the computer reading assignment. On the other hand, some fourth-grade students expressed difficulty with computer reading because they perceived words as being intentionally misplaced in the passage or questions. Fourth graders considered this misplacement confusing, but they also found it beneficial because it pushed them to work harder at understanding the reading passage. For fifth grade students, favorable performance outcomes seemed to provide confidence, especially at times when an assignment was followed by a quiz. Most fourth and fifth graders completed the computer reading assignment in a haste, anxiously, or with overconfidence. This latter behavior resulted in incorrect responses where students had to "reselect options" or "rephrase text in writing portion." The researchers also noted that computer praise and encouraging feedback resulted in overconfidence with many incorrect responses. As a few fifth graders admitted, overestimation of abilities sourced from reading assignments perceived as "boring and easy."

Students demonstrated self-efficacy when they completed paper-based reading tasks. The majority of second grade students read the text and responded to questions confidently and correctly; this, however, was not the case for two students who made mistakes in multiple-choice items and provided out-of-context open-ended responses. Some second graders with previous familiarity with the reading topic used less close reading strategies such as rereading, reflecting, or "checking back" to the passage. However, second graders stated that prior knowledge and memory capabilities instilled confidence in them: "I can know I can trust myself that I might just answer correct… because I've studied this. I look back in my brain is I've studied it in my memories. And so I basically have a computer in my brain" (boy, second grade). Reading assignments associated with testing caused anxiety for possible failure. To overcome fear of failure, second grade students reported using context clues or exerting a mental effort by "thinking about it until I get confident." Third grade students stated that reading was their favorite activity and that increased their self-confidence in successfully completing paper reading assignments. Third and fourth grade students appeared confident with completing the paper reading assignment. However, when the researcher reviewed completed assignments, there were incomplete multiple-choice responses, blanks, and irrelevant responses to questions. Third graders admitted that unfamiliar words decreased their understanding, but they overcame it with teacher assistance. Fourth grade students appeared able to complete paper-based reading assignments and stated a mastery of reading because "reading is pretty easy," but their open-ended responses in embedded charts were incomplete or incorrect. Students in fifth grade also appeared capable of reading and responding to all portions of a reading assignment, yet half of them had at least one incorrect or blank response, and some read the text several times. A few fifth graders stated that unfamiliarity with a topic reduced their confidence. Others indicated that the longer passages contributed to having a challenging and rewarding reading experience. Fifth graders found long passages challenging but they liked it because they could apply their reading comprehension skills.

We detected a sense of pride among older students in their ability to successfully complete paper reading assignments. Motivation and capability to read in print seemed beneficial and in agreement with past research (Pintrich, 1999; Soemer & Schiefele, 2018). In contrast, we detected a sense of decreased efficacy in completing computer reading assignments. The nature of the computer medium seemed to generate competence but also learning anxiety as others have found (McInerney et al., 1997; Wang & Wu, 2008).

Summary of Qualitative Findings

Students in primary grades demonstrated SRL metacognitive processes, and these were more common in the paper than in the computer condition. In relation to regulation of condition constructs, students showed signs of *planning* more in the paper than in the computer condition but student behaviors and responses differed between grades. *Monitoring* practices appeared in both the computer and the paper task, but monitoring relied on background knowledge in grades 2 and 3 and reading content in grades 4 and 5. *Control* processes such as retrying and organizing were more common in the computer- than in the paper-based reading. Close reading habits appeared more in paper than in computer reading assignments, whereas distractions influenced control strategies more in computer- than in paper-based reading. Students used their progress score in a reading task as an *evaluation* tool to assess performance in the computer and paper condition.

In relation to knowledge of cognition constructs, students demonstrated awareness of their thought process and behaviors (*declarative knowledge*) during both the paper and the computer reading task. Constant comparison between text and questions, teacher guidance, and hierarchical processes acted in favor of successful completion. In addition, students in grades 2 and 4 expressed emotional associations with grade acquisition or failure to complete computer and paper reading tasks. Students across grades did not explicitly state any self-learning or transfer of knowledge strategies (*conditional knowledge*) when completing a computer or paper reading assignment. Performance appeared to trigger successful completion across grades. Students provided more salient responses about rechecking, rereading, or response elimination strategies (*procedural knowledge*) in the paper than in the computer condition.

Motivational aspects of SRL that students exhibited included technical ability and self-efficacy. Students were able to orient and complete a reading task during both the computer and the paper reading tasks. Self-efficacious behavior appeared more frequently in the computer than in the paper condition.

Figures 4-6 highlight the main ideas associated with SRL metacognitive constructs in the computer- and paper-based reading condition.

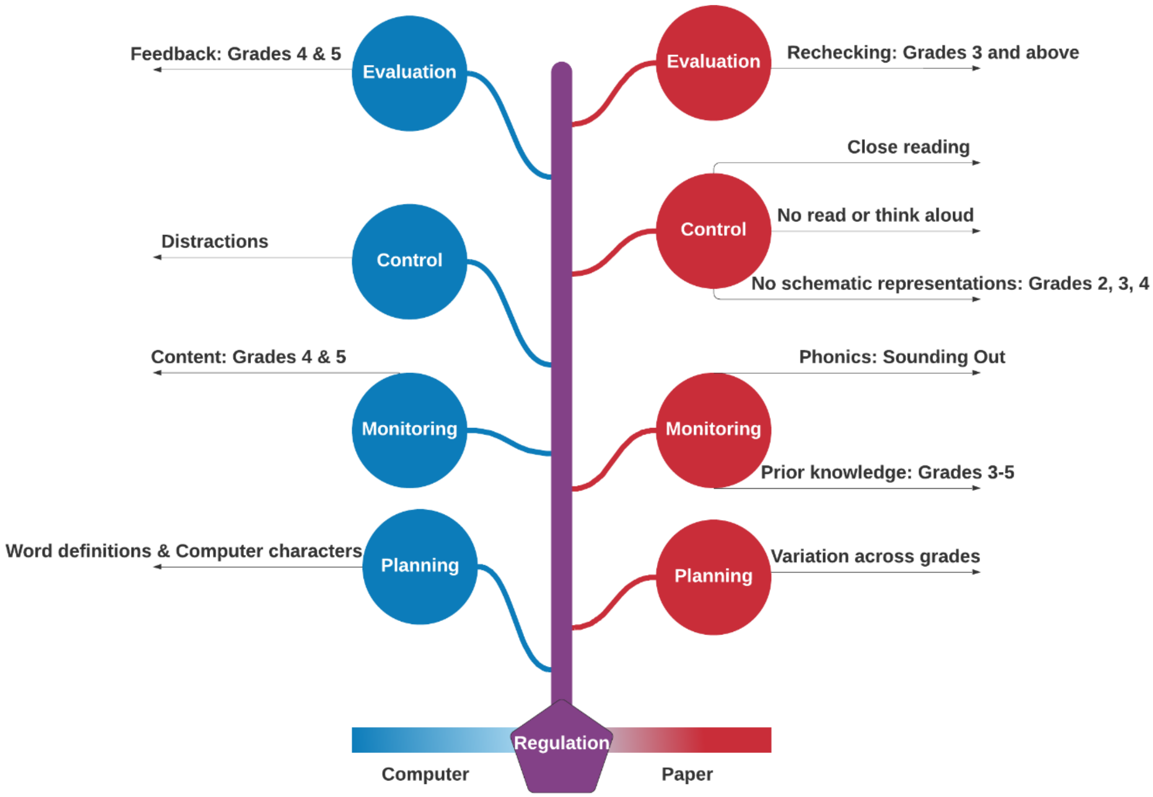

Figure 4. *Regulation of Cognition Main Qualitative Findings During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

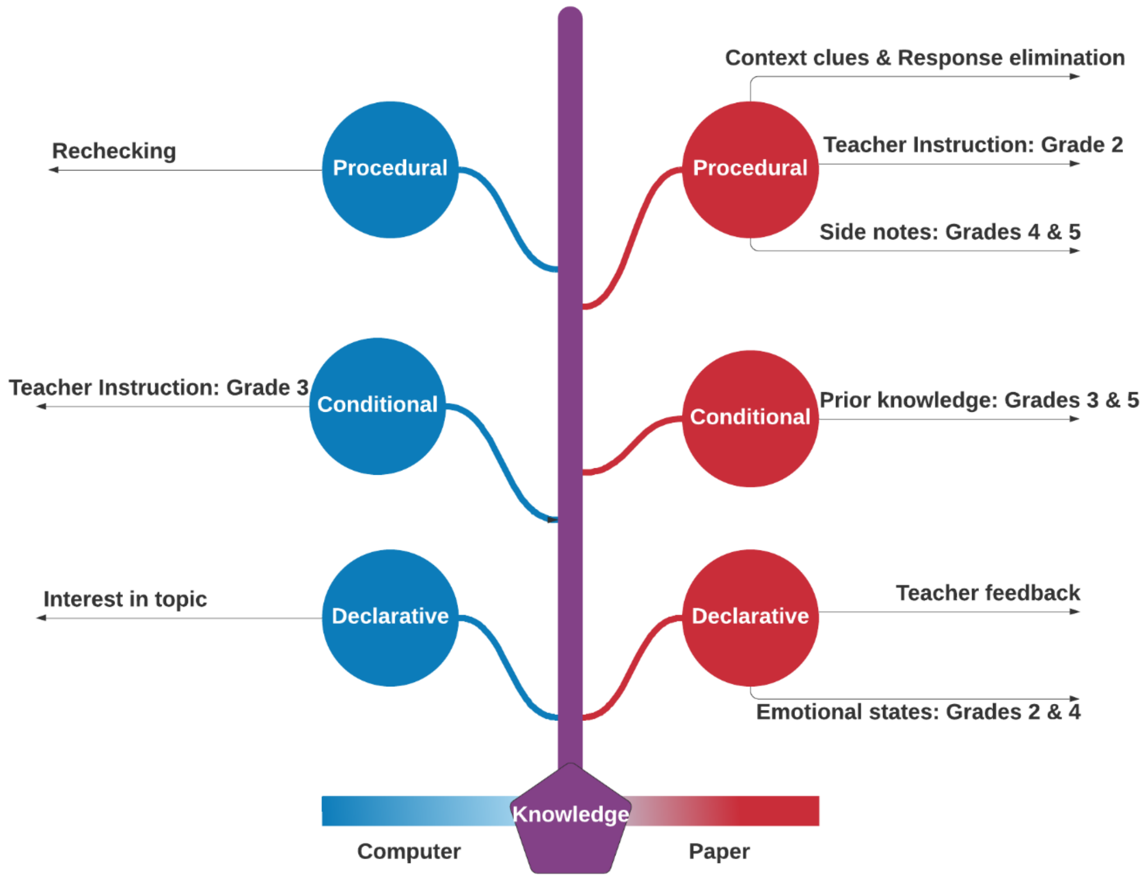

Figure 5. *Knowledge of Cognition Main Qualitative Findings During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

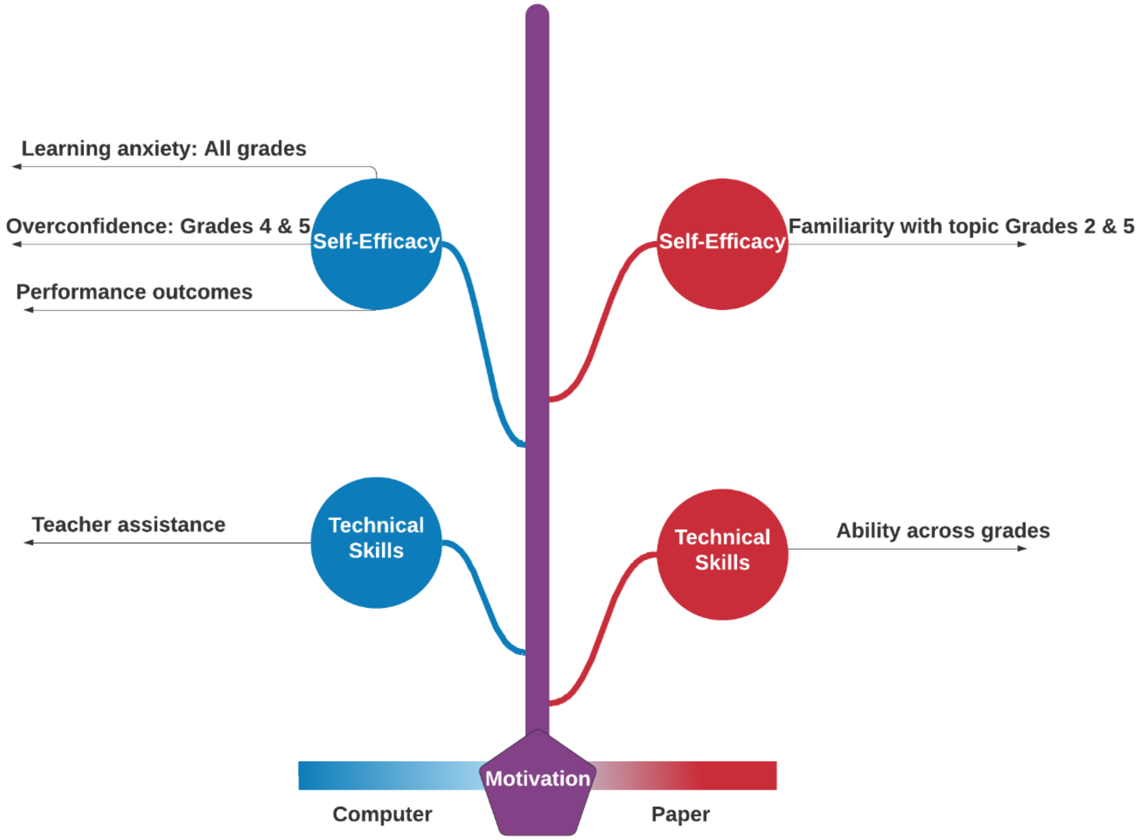

Figure 6. *Motivation Main Qualitative Findings During the Computer and Paper Conditions in Elementary Students in Grades 2-5.*

CHAPTER V

DISCUSSION

Overview

Our results indicated that children in early and late primary grades exhibit SRL metacognitive skills. These skills are mostly evident in paper-based reading assignments as others have shown (Halamish & Elbaz, 2020; Singer Trakhman et al., 2019). Examination of students' scores in individual grades provided further insights and showed that students in Grades 2 and 3 tended to apply SRL metacognitive skills to a greater extent in the paper condition than in the computer condition. Students in Grades 4 and 5 seemed to apply SRL metacognitive skills more in the computer condition than in the paper condition. Grade 4 seems to be a grade point where students tend to exhibit similar skills between conditions, which indicates sufficient familiarity with both reading medium formats, as others have suggested (Singer & Alexander, 2017). However, SRL metacognitive skills seem to fluctuate in fifth grade students, implying little effect of the medium format (Halamish & Elbaz, 2020). Furthermore, SRL metacognitive skills are demonstrated when students in early elementary grades (2 and 3) complete assignments using paper and pen, but in late elementary grades (4 and 5) flunctuate between computer and paper. These results are supported by prior research showing positive metacognitive and motivation effects of computer-based tasks in tertiary and secondary education students (Abrami et al., 2013; C.-M. Chen et al., 2019). In constrast, results from large systematic reviews and meta-analyses have suggested detrimental metacomprehension effects on students of elementary grades from reading on screens (Clinton-Lisell, 2019; Delgado et al., 2018). These differences could be attributed to lack of familiarity of younger and older elementary students with applying equally well metacognitive processes in screen and print reading assignments. Despite these mixed results, students in our study demonstrate specific judgements that lead to certain strategy use in both computer and paper reading, such as going back to the text, as previous research has shown (Hardcastle et al., 2017).

Regulation of Cognition Constructs

There were no differences in *planning* between computer- and paper-based reading or between grades. The lack of differences between computer and paper can be attributed to characteristics in each medium that elicit similar cognitive decisions. For example, students seem to be guided by similarly pre-determined visual aids (e.g., bold words, informational boxes) to plan both computer and paper reading. Room to apply new or spontaneous planning processes maybe minimal. In that sense, students may be able to transfer specific background knowledge to perform reading tasks in a computer or paper environment. Furthermore, the lack of differences between grades can be attributed to the complexity of reading tasks and differences in reading mastery that give rise to emotional states such as frustration. For example, reading proficiency, SRL strategies and performance in storytelling among 6-9 year old students has revealed that negative emotions may result in less planning strategies for these emerging readers (Buono et al., 2020). Hence, students are not able to detect difficulties in their reading and activate appropriate planning mechanisms (Griffith & Ruan, 2005). Previous research in high school and undergraduate students has featured planning in both computer and paper tasks (Follmer & Sperling, 2019; Manlove et al., 2007). In contrast, other research has indicated planning having no effects in elementary students using tablets (Muis et al., 2016). In regards to planning, our results suggest that students apply some level of planning to purposefully set learning goals and use strategies for attaining these goals, as Boekaerts (1997) has shown. Researchers have consistently shown the effects of planning to be present with older students and for different tasks, and the results of the current study expand these findings to students in elementary grades.

Additionally, there were no differences in *monitoring* between conditions and between grades. The computer and paper interface do not involve prompts for students to effectively monitor cognitive processes. For example, verbalization or think aloud of thought sequences is not enabled preventing students from asking questions to themselves or others. Also, visual cues may create an overexposure to information where critical details for comprehension are missed, according to digital and print reading studies in undergraduate and ten-grade students (Mangen et al., 2013, 2019). Out of the two reading modalities, students seem to utilize fundamental phonics approaches, such as sounding words out, at a greater intensity in the paper than in the computer condition. This monitoring strategy is computer-generated in computer-based reading suggesting that students rely on computer characters because students themselves have probably not received instruction to transfer the skill of monitoring to a different medium. Furthermore, one possible explanation for the lack of significant differences between grades is that students may not have learned to recognize errors or gaps in their reading that can lead to strategy choices, as theorists have suggested (Clements & Nastasi, 1999). Yet, some level of these processes was measured suggesting that even young students have the capacity to apply monitoring. A previous study in fourth to sixth grade students indicated that monitoring through guided feedback is one of the SRL mechanisms to improve literacy skills using electronic portfolios (Abrami et al., 2013). This finding is reinforced by a four-year longitudinal study about the ability to effectively monitor reading comprehension developed as a later skill among students of ages 7 to 11 (Oakhill & Cain, 2012). Also, past research has shown detrimental effects on metacognitive monitoring and reading comprehension among fifth grade students who use computer (Halamish & Elbaz, 2020), but positive metacognitive affordances in third to fifth grade students who read e-books (Connor et al., 2019). The present and past findings collectively suggest that monitoring processes may be present but reading ability and comprehension may act as antecedents in elementary students; thus, monitoring may have to be learned in any type of reading modality – digital and print.

The results from the inferential statistics showed that fifth-grade students had higher levels of *control* processes for the paper- than the computer-based reading task and that their levels of control during the paper-based task were greater than those of younger students. This finding is unlike past research showing that guided computer-based reading and writing instruction produces significantly higher levels of control learning strategies than traditional instruction in fourth-, sixth-, and eighth-graders (Ponce et al., 2013). This disparity from previous research cannot be easily explained. However, students in our study may have demonstrated high levels of control strategies during paper reading because they were familiar with them and knew how to apply them in paper-based reading. This awareness empowers students to become autonomous learners. Control strategies may be more developed in fifth graders who exert more automatic than conscious control processes to reading comprehension (Connor et al., 2015). The present quantitative data were cross-sectional and inferences on development cannot be directly made. It is possible, however, that students in upper elementary grades have stronger literacy skills than younger students resulting in automatic controlled processes as others have demonstrated (Vorstius et al., 2013). Nevertheless, our findings are in agreement with past research showing that learners apply control strategies and evaluate tasks to achieve goals (Efklides, 2011). On the other hand, the qualitative findings revealed that reading on computer poses greater distractions (computer characters one as such) for students than reading on paper, which may interfere with control strategies as others have shown (Panadero, 2017; Salmerón et al., 2021; Storz & Hoffman, 2013). Students engage in close reading more in the paper than in the computer condition because they seem to understand the features presented in the paper-based reading better than in the computer-based reading, as other researchers have consistently shown in middle and high school students (Kim & Kim, 2013; Mangen et al., 2013).

Furthermore, students across grades had higher levels of *evaluation* processes during computer- than paper-based reading tasks. This is a novel finding among elementary students extending prior research in students of lower and higher levels. Past research has shown that evaluation processes in computer-based assignments take the form of direct and explicit feedback (Andrade, 2019), as our findings indicate through the scaffolds my participants receive in the computer condition. This feedback provides opportunities for students to recheck and correct a response, thus persisting to successfully complete a task (Schunk & Ertmer, 1999). Evaluation of learning goals during computer-mediated reading generates instantaneous judgements of knowledge that can contribute to self-regulated learning, metacognition, and self-efficacy, as others have shown (Azevedo & Hadwin, 2005; Greene et al., 2010; Manlove et al., 2007). Among college students, evaluation is significantly associated with outcome expectations in computer-based science and history assignments (Deekens et al., 2018). Similarly, computer feedback in kindergarten students has been shown to result in higher levels of achievement in literacy skills than no feedback (Muis et al., 2015). Elementary students may exert greater evaluation processes during computer than paper reading assignments because in computer assignments students directly elicit personal judgements of present performance sourcing from immediate computer feedback (Schunk, 1996). As Zuercher (1989) argued, students rely on feedback and performance outcomes to evaluate their computer-based reading comprehension levels. Evaluation of learning goals during computer-mediated reading generates instantaneous judgements of knowledge that can contribute to self-regulated learning, metacognition, self-efficacy, and conscious decisions for optimal readng, as others have shown (Azevedo & Hadwin, 2005; J. A. Greene et al., 2010; Koriat, 2012; Lipko et al., 2009; Manlove et al., 2007). Furthermore, evaluating performance in a paper-based reading task can lead to rechecking and recalling of information (Singer & Alexander, 2017), as my qualitative data show.

Knowledge of Cognition Constructs

There were no differences in *declarative knowledge* and *procedural knowledge* between computer- and paper-based reading and between grades. Declarative and procedural knowledge relate to reading ability of students in primary grades. Students expressing similar thought processes regarding awareness and applicability of certain metacognitive processes in both conditions suggests that knowledge of cognition constructs are developing skills that require scaffolded instruction consistently across media. As research in students of grades 1-4 has indicated, the explicit knowledge of word correspondence and the knowledge of a flexible, almost automatic, set of reading skills are aspects of declarative and procedural functions respectively (Earle et al., 2020). My findings support the existence of these functions in our elementary students, yet with no differentiating effects between computer- and paper-based reading. This pattern may be attributed to the reading ability of students in Grades 2-5 and not to the medium. Students may have to receive focused instruction and sufficient practice in decoding and word recognition routines and learning strategies before they effectively transfer them between computer and paper reading, as others have shown (Bitan & Karni, 2004). Furthermore, earlier research has indicated that transfer of knowledge for reading concepts and procedures need certain consistency between reading interfaces (Harvey & Anderson, 1996). In our study, computer and paper reading shared some common features, such as informational boxes and hints, but the participating students did not seem to make the necessary mental connections for reading representations and processes (Kendeou et al., 2003; Kendeou & van den Broek, 2007). Furthermore, familiarity with processes appears to be a factor more when reading on paper than reading on computer. One possible reason is that younger and older students recognize that seeking appropriate strategic remedies is beneficial to comprehend paper-based texts, as have been documented in research with students of Grades 3, 5, and 7 (Garner et al., 1986). As students try to trigger appropriate SRL strategies to comprehend and complete a reading task their sources of knowledge stem from familiar patterns and teacher guidance, as literacy research on fifth and sixth graders has also shown (Kock & Harskamp, 2016; Nielsen, 2017).

Students showed significantly higher levels of *conditional knowledge* during paper- than computer-based reading tasks. These results agree with other studies showing that students in fifth grade apply multiple sources to guide their SRL choices in literacy instruction (Connor et al., 2015; Hattan & Dinsmore, 2019) and that task orientation of preschoolers and kindergarteners affects SRL measures (Bierman et al., 2014; Nielsen, 2017). Furthermore, typologies of reading applications in undergraduate students have revealed that reading a text serves the purposes of assessment, obtaining information, and enjoyment (Lorch et al., 1993). This suggests that students recognize which strategies are relevant across reading texts and tasks, but this is apparently more evident in paper than computer reading, as other research in students of grades 3, 5, and 7 has shown (Garner, 1990). As my qualitative findings indicate, students associate reading comprehension with text interest and prior knowledge regardless of reading on computer or paper. This finding implies that students to some extent have the ability to decode instructions and perform cognitive representations for familiar reading tasks, as found in information-processing literature (Harvey & Anderson, 1996).

Other Motivation Constructs

Motivational aspects such as *technical ability* (e.g., navigation ease) and *self-efficacious* behavior (e.g., completion ability) are evident in both conditions, and students exhibited similar levels between conditions and grades. Students' own capabilities to complete a reading task in digital or print form most likely stems from similar exposure and familiar experiences with each medium (Igbaria & Iivari, 1995; Lim & Jung, 2019). The lack of a non-significant effect between conditions agrees with past research on fourth grade students and their literacy skills in ePIRLS (the computer-based version of PIRLS-The Progress in International Reading Literacy Study assessment), which was attributed to non-equal access and low socioeconomic status (SES) of students (Combrinck & Mtsatse, 2019). Even though we cannot directly infer on an association between social factors and reading comprehension, my results suggest that reading skill may contribute to significant differences between computer- and paper-based reading comprehension. SES could play a mediating role to students' exposure to reading opportunities – print or digital, but this could be an area for future investigation. Furthermore, technical skils could be attributed to students having knowledge of all technical conventions of reading in computer and paper, as other researchers have suggested for students aged 8-9 years (Ottaviano et al., 2004) and for computer versus paper reading interventions where the medium produced no difference on reading performance (Askwall, 1985; Singer & Alexander, 2017). In terms of self-efficacy, students' beliefs seem task-related. The specificity of a reading task guides certain self-regulatory strategies (e.g., rechecking, asking questions), shown slightly more in the paper- than in the computer-based reading (Mangen et al., 2013; Rumelhart & Norman, 1980). The variation across grades indicates that functions of each medium are still learned, as others have indicated for students in Grades 4 to 7 (Amendum et al., 2018; Pajares & Valiante, 2002). Therefore, transfer of knowledge is not yet replicated across conditions, which seems to impact choice of SRL strategy.

Unique Contributions of This Study

The present study produces converging results with past research. At the same time, it expands previous findings by generating unique contributions, listed here. First, the present study was conducted in a naturalistic setting – actual computer classrooms, using authentic reading texts that students usually complete either on screen or in print. This is unlike past research that tends to follow interventional study designs, using controlled treatments. The benefit of the naturalistic (descriptive) design is that a researcher merely documents the presence and intensity of outcomes without interfering with a study's treatment outcomes (Aggarwal & Ranganathan, 2019).

Additionally, this study contributes to generating a taxonomy of SRL metacognitive processes that can be helpful in computer- and paper-based reading instruction. The array of classifications attest to shared and unique SRL thought processes and behaviors in the two reading modalities. Specifically, the following key processes are recorded in each SRL metacognitive dimension:

- *Planning* – rely on computer narration (computer); read entire text (paper); pinpoint with pencil (paper) / cursor (computer); look for definitions (both conditions); look at reading genre and topic (both conditions).
- *Monitoring* – rely on computer feedback (computer); use context clues (paper); sound words out (paper); ask questions (both conditions); recheck answers (both conditions); reread text (both conditions).
- *Control* – organize responses in charts (computer); use information and multimedia cues (computer); apply close reading habits (paper); apply surface-level strategies, e.g., circling, underlining (paper); perform response elimination (paper).
- *Evaluation* – rely on interactive multimedia (computer); go back to the text (paper); use performance score (instantaneous in computer / delayed in paper).
- *Declarative knowledge* – read text alongside questions (computer); show interest in text (computer); boredom (computer); emotional discomfort (paper); teacher guidance (both conditions).
- *Conditional knowledge* – remember information (computer); performance outcomes (computer); text familiarity (paper); prior knowledge (paper).
- *Procedural knowledge* – informational buttons (computer); word clues (paper); low-utility methods, e.g., circling, marking (paper); reread text (both conditions); teacher guidance (both conditions).
- *Technical skills* – home advantage (computer); passage indentations (paper); numbering of text lines and questions (paper); teacher assistance (both conditions).

- *Self-efficacy* – listen to character narration (computer); reading motivation (computer); learning anxiety (computer); reread text (paper); performance outcomes (both conditions).

This juxtaposition of SRL metacognitive practices in both computer and paper reading tasks can yield protocols for effective SRL instruction in students of elementary grades who attend traditional and virtual classroom environments.

Finally, the present research reveals that scaffolding features embedded in computer-mediated tasks seem to limit the application of SRL metacognitive practices. Narration from computer characters, gradual appearance of text, disabling of previous screens are examples that may hinder sounding out, mental representations of text, reading entire passage for comprehension, or rechecking a passage. In that regard, SRL metacognitive thoughts and behaviors that occur in computer reading may have to be re-envisioned, so that computer-based reading instills parallel SRL skills to paper-based reading.

Implications

The present results have implications for theory and practice. From a theoretical standpoint, our results expand theoretical assumptions in the literature of SRL and metacognition. Elementary grade students show emerging traits to regulate their learning and awareness of their cognitive capabilities in comprehending and completing reading tasks. Based on our quantitative results, students control, evaluate, and know when (conditional knowledge) to use a learning strategy. These metacognitive SRL processes are developed enough to differentiate between two reading modalities – prominence of control and conditional knowledge in paper, whereas prominence of evaluation in computer. The multidimensional aspect of metacognition is comprised of interconnected thought processes and regulatory skills, such as setting goals, monitoring, and evaluating that motivate learners and improve academic performance (Brown et al., 1981; Flavell, 1979; Pintrich & de Groot, 1990). As our quantitative and qualitative results collectively indicate, elementary students have to learn to transfer and apply regulatory and cognitive strategies between reading media. Figure 7 encompasses the SRL metacognitive constructs and associated dimensions. The diagrams provide a broader conceptual understanding of the ways SRL is situated in reading tasks and show the interconnected relations to improve SRL features in reading.

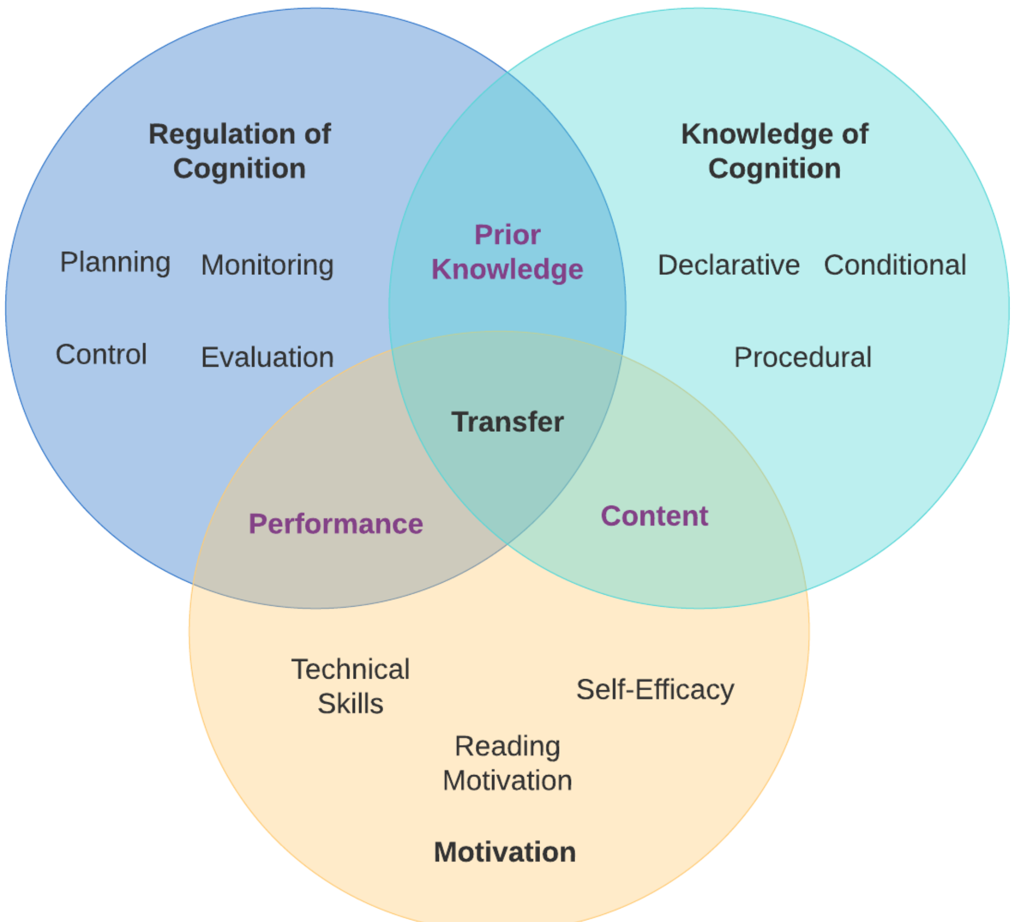

Figure 7. *Conceptual Map of SRL Metacognitive Constructs*

From a practical standpoint, our results point to metacognitive SRL strategies being acquired skills that can help students read and complete reading tasks effectively. Planning, monitoring, control, and evaluation are ways to restore deficiencies in reading while performing computer- and paper-based tasks. These processes are partially evident in computer and paper reading and across grades. Especially in computer-based reading, features of the medium itself seem to be confounding factors because they tend to hinder SRL practices, for example by the gradual appearance of a passage or the feedback from the animated characters. These elements may interrupt SRL thought process and actions and disable students' own SRL capabilities. Students in computer-based reading tasks can learn to set goals, ask themselves questions, read aloud, perform decoding and phonemic exercises without relying on computer characters that strips independent learning. Students in both conditions can improve cognitive deficiencies by cultivating cognitive schemas (memory, attention) that facilitate connections with different reading genres. Schematic representations using story maps, diagrams, and tables can potentially contribute to forming cognitive connections and applying SRL strategies. Likewise, modeling and scaffolded instruction can focus on the process of acquiring SRL skills especially in low-stake and non-graded reading assignments. Finally, students across grades can collaborate during computer- and paper-based reading tasks in ways that promote knowledge sharing, peer interaction, and motivate high- and low-skill readers.

Limitations and Strengths

A mixed-method model was employed to examine key SRL metacognitive processes during computer and paper reading tasks across students in Grades 2-5. Despite the strength of this between-within approach that allowed students to be control of themselves, the current study had several limitations. The study employs a cross-sectional design which provides an one-time view of SRL metacognitive practices. The focus is on describing differences and not changes over time, as a longitudinal design can attest. Also, reading fluency was not one of the examined measures with a potential influence on metacognitive SRL processes. Furthermore, overly generalizations cannot be made because the sample was mostly middle class students drawn from the public after-school programs in a single school district. Finally, this study was one of the few that employed a general-base SRL instrument in two reading formats yielding rather low levels of construct validity. Especially in observations, the reliability scores of the instrument posed a challenge because they demonstrated a few low intercorrelations among indivual items. This was partially due to the very small number of items in some SRL dimensions. Another reason for the low reliability scores was the cognitive depth of some items which seemed unparallel to the metacognitive ability of students in early grades. This resulted in less than optimum between-person variation in scores.

Regardless of these limitations, the present study embodies certain strenghts worth discussing. This is one of the few studies where direct descriptions drawn from a naturalistic setting are made between metacognition and SRL processes and two popular reading modalities – computer and paper. Furthermore, students did not undergo a deliberate treatment; rather, study conditions imitated authentic reading tasks on computer and paper. Also, triangulation of methods generated a plethora of in-depth findings. Incorporating observations, ratings, and semi-structured interviews generated results that complemented each other and provided insights that would not be evident should only one methodological approach was pursued.

Future Research

Metacognitive research of the last twenty years strives to depict a profile of students who regulate and are consciously aware of their thoughts and actions (McCormick et al., 2013;

Pressley, 2002). Yet, metacognitive research has not performed equally long strides regarding the metacognitive practices of teachers: how teachers set goals for reading instructions; how teachers monitor reading comprehension not as a function of a scoring system but as a result of thought processes; what teachers do to model metacognitive SRL strategies to increase comprehension during reading tasks; do teachers perform think alouds in front of their students for vicarious comprehension strategies; do teachers include class discussion of reading strategy use in authentic texts (not practice pages); or, do teachers model across both paper and online contexts or only in one? Therefore, research on teachers' higher-order instructional practices will be far more likely to produce students who exhibit those self-monitoring and regulatory behaviors and can contribute to the advancement of metacognitive SRL processes in school settings. In terms of measurement, replication of the current study in the same context can aid the reliability and validity scores of the instrument, thus producing effective SRL items for reading-related tasks in computer and on paper. In particular, the instrument items can be enriched with statements from the qualitative findings and be linguistically softened to align with the developmental level of students. This can produce nuanced differences. Also, future research can highlight the effects of emotions and distractions on student reading engagement and associated SRL practices. Finally, longitudinal examinations will solidify inferences and extend generalizability of conclusions as students advance in grades and strengthen their reading skills. Through the lens of self-regulated learning and metacognition, it is possible to reinforce technology into instructional practices for reading and create a rich environment that meets the digitization needs of 21st-century learners and workforce.

Conclusions

The motivation for conducting this study was the increasing use of computers in educational settings, as a form to present and comprehend reading texts. Two reading modalities – computer and paper – were presented to students in grades 2 to 5. The measurement of SRL metacognitive and motivational constructs show that paper-based reading tasks implicate regulatory and knowledge strategies to a greater extent than computer-based reading tasks. Furthermore, younger students possess emerging SRL skills which in older students maybe developed but not well articulated. In light of these results, a need for intentional instruction and knowledge transfer for SRL processes from paper to computer reading environments is highlighted. Such actions will contribute to the pedagogical functions of digitified education and to the skill acquisition of 21st Century learners – traditional and online.

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APPENDIX A

MISSISSIPPI STATE UNIVERSITY INTERNAL REVIEW BOARD'S NOTICE OF APPROVAL FOR HUMAN RESEARCH

MISSISSIPPI STATE
UNIVERSITY

Office of Research Compliance

Institutional Review Board for the Protection of
Human Subjects in Research
P.O. Box 6223
53 Morgan Avenue
Mississippi State, MS 39762
P. 662.325.3294

www.orc.msstate.edu

NOTICE OF DETERMINATION FROM THE HUMAN RESEARCH PROTECTION PROGRAM

DATE:	September 20, 2019
TO:	Anastasia Elder, PhD, Counseling Ed Psyc & Foundations, Jianzhong Xu;Kristin Javorsky;Tianlan Wei
	Jianzhong Xu, Counseling Ed Psyc & Foundations, Kristin Javorsky, PhD, Curriculum Instruction & Special Ed, Katerina Sergi, MA, Tianlan Wei, PhD, Counseling Ed Psyc & Foundations
PROTOCOL TITLE:	Computer-Based Education and Self-Regulated Metacognitive Processes Among Early and Middle Elementary Students
PROTOCOL NUMBER:	IRB-19-315
APPROVAL PERIOD:	Approval Date: September 20, 2019 Expiration Date: September 19, 2024

Under an expedited review procedure, the research project identified above was approved on September 20, 2019 by the Mississippi State University Institutional Review Board (MSU IRB). The application qualified for expedited review under CFR 46.110, Category 7.

This memorandum is your record of the IRB approval of this study. Please maintain it with your study records.

Please note that the MSU HRPP accreditation for our human subjects protection program requires an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. **If applicable, you must use the stamped consent form for obtaining consent from participants.**

The MSU IRB approval for this project will expire on September 19, 2024. If you expect your project to continue beyond this date, you must submit an application for renewal of this HRPP approval. HRPP approval must be maintained for the entire term of your project.

If, during the course of your project, you intend to make changes to this study, you must obtain approval from the HRPP prior to implementing any changes. Upon becoming aware of an unanticipated problem that suggests participants or others are at greater risk of harm than was previously known or recognized, a problem report must be submitted to the HRPP as soon as possible, but always within 10 days. Serious problems must be reported verbally within one business day, in addition to the submission of the written Problem Report.

You are required to maintain complete records pertaining to the use of humans as participants in your research. This includes all information or materials conveyed to and received from participants as well as signed consent forms, data, analyses, and results. These records must be maintained for at least three years following project completion or termination, and they are subject to inspection and review by the HRPP and other authorized agencies.

Please notify this office when your project is complete. Upon notification, we will close our files pertaining to your project. Reactivation of the HRPP approval will require a new HRPP application.

If you have any questions relating to the protection of human research participants, please contact the HRPP by phone at 662.325.5220 or email irb@research.msstate.edu. We wish you the very best of luck in your research and look forward to working with you again.

Approval Period:	September 20, 2019 through September 19, 2024
Review Type:	EXPEDITED
IRB Number:	IORG0000467

Figure A1. Internal Review Board Approval Letter

MISSISSIPPI STATE UNIVERSITY HUMAN RESEARCH PROTECTION PROGRAM	**Parental or Legally Authorized Representative Permission Form *Version 5/28/19***

Mississippi State University
Parental or Legally Authorized Representative Permission Form
for Participation in Research

You are being asked to allow your child to participate in a research project. This form provides you with information about the project. Please read the information below and ask any questions you might have before deciding whether or not to allow your child to participate.

IRB Approval Number: IRB-19-315

Title of research project: Computer-Based Education and Self-Regulated Metacognitive Processes Among Early and Middle Elementary Students

Site of research project: Two after-school programs in Starkville Oktibbeha Consolidated School District:

1) Extended Day Program at Sudduth Elementary (grades 2-5);
2) 21st Century Community Learning Centers at Henderson Ward Stewart (grade 2) and Overstreet Elementary (grade 5).

Name of researcher(s) & University affiliation: Dr. Anastasia Elder, PhD (lead PI and Advisor, Mississippi State University) and Katerina Sergi (student researcher, Mississippi State University.)

The purpose of this research project:
This dissertation study will investigate how students monitor and evaluate their reading comprehension while on a computer and while looking at print on paper. The study will involve observations and semi-structured interviews with students.

We hypothesize that computer-based approaches are associated with students monitoring and evaluating their academic performance when completing a reading assignment.

If you agree to allow your child to participate in this research project, we will ask your child to do the following things:

- Meet with your child four times: two in the fall and two in the spring. In the fall, your child will participate in a session consisting of an observation and an interview. The observation will involve a reading assignment on computer, where your child will login to their i-Ready account and the researcher will record the student's behavior in a checklist. The interview will follow with the researcher asking about your child's thought processes in completing the computer-based reading task.
- After a few days, this process will be repeated, but this time the observation and the interview will be for a paper-pencil reading assignment.
- In the spring, your child will be asked to participate in two sessions similar to the fall. The content of the reading assignment will be according to the reading material learned in the spring.

MSU HRPP
Approved: 09/20/19 Expires: 09/19/24
IRB # 19-315

Figure A2. *Internal Review Board Approved Parental Consent Form*

- The order of conditions (computer and paper-pencil) will be randomly assigned to each child in fall and spring. In the computer assignment, the first and last screen of i-Ready will be photographed to record the reading topic and the completion rate. In the paper assignment, the reading worksheets will be collected.
- Interviews with your child will be audio-recorded. Your child's reading scores in their standardized reading assessment will be collected in fall and spring to make comparisons about your child's learning in reading.

The total estimated time to participate in this research project: Each observation and interview will last 35 minutes.

The risks of participation:

- The proposed research does not entail any higher degree of risk than similar activities during school.

The benefits of participation:

- Students will practice their reading skills by completing an instructional reading assignment in their after-school program. Additional benefits will include students exercising thought processes that will help them with their academic performance in reading.

Compensation:

- As a thank you for participating in this study, students will receive a gift prize to the skate rink each time they complete an observation and interview. The total value of the gift prize will be $10 for all four observations and interviews.

Confidentiality and privacy protections:

- We will include statements where students understand they have the right to choose when, how, and to what extent to share information about themselves. We will also protect student's identity by using ID codes on instruments and worksheets, e.g., student ID 901, student ID 902 and so on. We will also ask your child to give us a preferred pretend name from one of their favorite reading characters. ID codes and student responses will be saved and stored separately. Access to documents and forms will be restricted to the primary investigator and student researcher. The location will be the student researcher's password-protected desk computer and key-protected work desk drawer. Furthermore, all quantitative data will be reported in aggregate form with no linkages to personally identifiable information, and all qualitative data will be reported as themes with occasional actual student utterances reported for reinforcement of a finding.
- It is important to understand that these records will be held by a state entity and therefore are subject to disclosure if required by law.

MSU HRPP
Approved: 09/20/19 Expires: 09/19/24
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Figure A2. (continued)

Contacts and questions:

- If you have any questions or want additional information, please contact Katerina Sergi at 662-722-1271 or ks1894@msstate.edu. For information regarding your rights as a research subject, please contact the MSU Research Compliance Office at 662-325-3994.

If you do not want your child to participate:
Please understand that your child's participation is **voluntary.** Your refusal to allow your child to participate will involve **no penalty** or loss of benefits to which you or your child is otherwise entitled. You may discontinue your child's participation **at any time** without penalty or loss of benefits. Your child may skip any items that he or she chooses not to answer. Your refusal will not impact current or future relationships with Mississippi State University. To do so, simply tell the researcher that you wish to stop.

If after reading the information above, you agree to allow your child to participate, please sign below. If you decide later that you wish to withdraw your permission, simply tell the researcher. You may discontinue your child's participation at any time. You will be given a copy of this form for your records. Please return the signed forms to your child's after-school site supervisors.

____
Child's name (please print)

____
Parent or *Legally Authorized Representative's Signature Date

____
Investigator's Signature Date

If a Legally Authorized Representative (rather than a parent), must have documentation to show LAR status.

Research Participant Satisfaction Survey

In an effort to ensure ongoing protections of human subjects participating in research, the MSU HRPP would like for research participants to complete this anonymous survey to let us know about your experience. Your opinion is important, and your responses will help us evaluate the process for participation in research studies.
https://www.surveymonkey.com/r/M5M95YF

MSU HRPP Approved: 09/20/19 Expires: 09/19/24 IRB # 19-315

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Figure A2. (continued)

MISSISSIPPI STATE UNIVERSITY HUMAN RESEARCH PROTECTION PROGRAM	**Assent Form** *Version 5-28-19*

IRB Approval Number: IRB-19-315

Project Title: Computer-Based Education and Self-Regulated Metacognitive Processes Among Early and Middle Elementary Students.

Investigators: Anastasia Elder and Katerina Sergi.

My name is Katerina Sergi and I work at Mississippi State University. I would like to tell you about a research study that involves kids like you. A research study is a way to learn more about people. We are doing a research study about what students do when they use computers and worksheets at school to complete a reading assignment. Your parent knows that we are going to ask you to participate in this study. If you decide to be in this study, we will ask you to do a reading assignment, once in i-Ready and once on paper, once in the fall and once in the spring, for a total of four meetings at the after-school program. As you complete the reading assignment, I will be writing down what you do. This is called observation. When you finish, I will ask you questions about the ways you completed the reading assignment. This is called interview. The research study will last about 35 minutes and you will receive a gift prize to the skate rink each time you complete an observation and interview.

There are some more things about this study you should know:

- During one of our meetings, we will ask you to login to your i-Ready account. I will take a picture of the first screen.
  - As your complete the computer reading assignment, you can read aloud, or ask questions. You will also have blank sheets to use as scrap paper.
  - I will take a picture of the last screen of your computer reading task results.
- After a week or so, I will come to meet you again. This time I will ask you to complete a reading assignment on paper.
  - I will hand you the reading assignment on paper. Again, you can read aloud, or ask questions. You will also have blank sheets to use as scrap paper.
  - When you complete the paper reading assignment, I will collect it.
- I will use an audio-recorder to help me remember what you said during our interview.

Some questions may be more difficult than others but there are no right or wrong answers. We just want to know what you would do or say. You may skip any question that you do not want to answer, and you may take a break if you need one. If you feel upset by any of the questions or if you cannot answer a question, please tell me. I am here to help.

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We think these benefits might be practicing your reading skills by completing assignments in computer and on paper.

When we finish this study, we will write a report about what we learned. Your name will not appear on the report, we will use a pretend name of your choice.

MSU HRPP	Approved: 09/20/19	Expires: 09/19/24
	IRB # 19-315	

Figure A3. *Internal Review Board Approved Child Assent Form*

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too.

If you decide you want to be in this study, please sign your name.

______ *Yes, I'll be in the study.* ______ *No, I do not want to be in the study.*

Participant's Name (Please Print):____

____

Signature Date

____

Investigator's Signature Date

Research Participant Satisfaction Survey

To make sure that your rights as a research participant have been protected, the MSU HRPP would like for you to complete this survey to let us know about your feelings of this study. Your answers will help us make sure that research participants are protected. ***https://www.surveymonkey.com/r/M5M95YF***

Figure A3. (continued)

APPENDIX B

CHECKLIST USED IN OBSERVATIONS AND INTERVIEW ITEMS USED IN RATINGS AND DISCUSSION PROMPTS

Table B1

Study Instrument: Observation Checklist

Total Time for Observation and Interview:	minutes	seconds
Date:		

OBSERVATION CHECKLIST

Student Name:			Student Assigned ID:	
Preferred Name:				
Grade Level:	☐ 2	☐ 3	☐ 4	☐ 5
Condition:	☐ Computer		☐ Paper & Pencil	
Reading Topic:				
Total Items Correct:				
Time Started:			Time Finished:	

Before we start I would like to ask you three things:

Warm-up Questions	**Never (0)**	**Sometimes (1)**	**Always (2)**
Do you find reading interesting?			
Do you look forward to reading?			
Do you find reading enjoyable?			

Start observation:

Item	**Observed (1)**	**Not Observed (0)**	**Researcher Notes**
Technical Skills			
1. Student knows how to orient to the computer program / worksheet.			
2. Student knows how to use the computer mouse (computer-based only).			
3. Student knows where to start and finish.			

Table B1 (continued)

Item	Observed (1)	Not Observed (0)	Researcher Notes
Self-Efficacy			
4. Student can understand the content of the reading assignment by answering correctly each question.			
5. Student is confident with his/her reading skills.			
6. Student can complete the reading assignment using computers / worksheets.			
Planning			
7. Student reads the entire screen / worksheet before he/she starts working.			
8. Student makes side notes (annotations) before answering a question.			
Monitoring			
9. Student thinks aloud of several ways to complete the assignment.			Record:
10. Student asks questions to complete assignment.			Record:
11. Student reviews answer before moving to the next question.			
Control – Learning Strategies			
12. Student draws pictures or diagrams to help understand content.			
13. Student reads questions aloud.			
14. Student pays attention to visual cues.			
15. Student pays attention to auditory cues (computer-based only).			
16. Student shows undivided attention to the computer screen / worksheet.			
17. Student stops and reads again when he/she gets confused.			
18. Student chooses the best answer to complete the assignment.			

Table B1 (continued)

Item	Observed (1)	Not Observed (0)	Researcher Notes
Evaluation			
19. Student goes back to previous screen / previous question to check response.			
20. Student looks for hints of successful completion.			

Table B2

Study Instrument: Semi-Structured Interview

SEMI-STRUCTURED INTERVIEW

Start interview and audio-recorder:

Item **When I complete a reading assignment on computer …… /** **When I complete a reading assignment on pen and paper……..**	**Never (0)**	**Sometimes (1)**	**Always (2)**	**Ask a follow-up question:** *Why do you say that?*
Technical Skills				
1. I know my way to the computer program / worksheet.				
2. I know how to use the computer mouse (computer-based only).				
3. I know where to start and finish.				
Self-Efficacy				
4. I can understand the content of the reading assignment.				
5. I am confident with my reading skills.				
6. **(skip prompt)** I can complete the reading assignment using computers / worksheets.				

Table B2 (continued)

Item **When I complete a reading assignment on computer …… /** **When I complete a reading assignment on pen and paper……..**	**Never (0)**	**Sometimes (1)**	**Always (2)**	**Ask a follow-up question:** *Why do you say that?*
Knowledge of Cognition – Declarative Knowledge				
7. I know when I understand something.				
8. I know what the teacher expects me to learn.				
9. I learn more when I am interested in the topic.				
10. I am good at remembering information.				
Knowledge of Cognition – Conditional Knowledge				
11. I can make myself learn when I need to.				
12. I learn best when I already know something about the topic.				
Knowledge of Cognition – Procedural Knowledge				
13. I try to use ways of completing the assignment that have worked for me before.				
14. I know the best ways to complete the assignment.				

Table B2 (continued)

Item **When I complete a reading assignment on computer …… /** **When I complete a reading assignment on pen and paper……..**	**Never (0)**	**Sometimes (1)**	**Always (2)**	**Ask a follow-up question:** *Why do you say that?*
Regulation of Cognition – Planning				
15. I think of several ways to answer a question and then choose the best one.				
16. I think about what I need to learn before I start working.				
17. I make side notes (annotations) before answering a question.				
Regulation of Cognition – Learning Strategies				
18. I draw pictures or diagrams to help me understand while learning.				
19. I really pay attention to important information/signals.				
20. I read questions aloud.				
Regulation of Cognition – Monitoring				
21. I ask myself how well I am doing while I complete an assignment.				
22. I check my answers before moving to the next question.				

Table B2 (continued)

Item **When I complete a reading assignment on computer …… /** **When I complete a reading assignment on pen and paper……..**	**Never (0)**	**Sometimes (1)**	**Always (2)**	**Ask a follow-up question:** *Why do you say that?*
Regulation of Cognition – Evaluation				
23. I stop and go back over new information that is not clear.				
24. I stop and reread when I get confused.				
25. When I am done with my assignment, I ask myself if I learned what I wanted to learn.				
26. I know how well I did once I finish.				

Table B3

Survey Instrument: Other Characteristics

OTHER CHARACTERISTICS

27. Student Age:		28. Gender:	Female	Male
29. Race: African-American	Asian	White	Other	
30. Frequency of using computers in school:		Days	Duration:	
31. Purpose of using computers in school:				
Standardized Tests	Quizzes	Practice Learning	Other	
32. Frequency of using worksheets in school:		Days	Duration:	
33. Purpose of using worksheets in school:				
Standardized Tests	Quizzes	Practice Learning	Other	
34. Participation in reduced school lunch program:		Yes	No	

APPENDIX C

FREQUENCIES OF OBSERVED CONSTRUCTS

Table C1

Frequencies of Regulation of Cognition Constructs in Elementary Students in Grades 2-5

			Computer					Paper				
				Observed		Not Observed			Observed		Not Observed	
Dimension	**Observation Items**	**Grade**	**N**	**Count**	**%**	**Count**	**%**	**N**	**Count**	**%**	**Count**	**%**
Planning	Reads Entire Screen / Worksheet	2	9	7	78	2	22	8	7	88	1	13
		3	14	12	86	2	14	14	14	100	0	0
		4	17	14	82	3	18	16	15	94	1	6
		5	11	8	73	3	27	12	12	100	0	0
	Makes Side Notes (Annotations)	2	9	0	0	9	100	8	0	0	8	100
		3	14	0	0	14	100	14	1	7	13	93
		4	17	0	0	17	100	16	0	0	16	100
		5	11	0	0	11	100	12	0	0	12	100
Monitoring	Thinks Aloud	2	9	1	11	8	89	8	1	13	7	87
		3	14	0	0	14	100	14	0	0	14	100
		4	17	0	0	17	100	16	0	0	16	100
		5	11	0	0	11	100	12	0	0	12	100
	Asks Questions	2	9	1	11	8	89	8	7	87	1	13
		3	14	1	7	13	93	14	10	71	4	29
		4	17	2	12	15	88	16	6	38	10	62
		5	11	1	9	10	91	12	8	67	4	33
	Reviews	2	9	8	89	1	11	8	7	87	1	13
		3	14	10	71	4	29	14	13	93	1	7
		4	17	17	100	0	0	16	14	88	2	13
		5	11	9	82	2	18	12	12	100	0	0

Notes. These constructs were evaluated by observation (Observed vs. Not Observed) using an adaptation of the Jr. MAI (Sperling, et al., 2002) and the original MAI scale (Schraw & Dennison, 1994).

Table C1 (continued)

			Computer					Paper				
				Observed		Not Observed			Observed		Not Observed	
Dimension	**Observation Items**	**Grade**	**N**	**Count**	**%**	**Count**	**%**	**N**	**Count**	**%**	**Count**	**%**
Control	Draws Diagrams	2	9	0	0	9	100	8	0	0	8	100
		3	14	0	0	14	100	14	3	21	11	79
		4	17	0	0	17	100	16	0	0	16	100
		5	11	0	0	11	100	12	5	42	7	58
	Reads Aloud	2	9	1	11	8	89	8	1	13	7	87
		3	14	0	0	14	100	14	4	29	10	71
		4	17	0	0	17	100	16	0	0	16	100
		5	11	0	0	11	100	12	1	8	11	92
	Visual Cues	2	9	9	100	0	0	8	7	87	1	13
		3	14	14	100	0	0	14	7	50	7	50
		4	17	17	100	0	0	16	10	62	6	38
		5	11	11	100	0	0	12	12	100		
	Auditory Cues	2	9	9	100	0	0	8	n/a			
		3	14	11	79	3	21	14				
		4	17	14	82	3	18	16				
		5	11	11	100	0	0	12				

Notes. These constructs were evaluated by observation (Observed vs. Not Observed) using an adaptation of the Jr. MAI (Sperling, et al., 2002) and the original MAI scale (Schraw & Dennison, 1994).

Table C1 (continued)

			Computer					Paper				
				Observed		Not Observed			Observed		Not Observed	
Dimension	**Observation Items**	**Grade**	**N**	**Count**	**%**	**Count**	**%**	**N**	**Count**	**%**	**Count**	**%**
Control	Shows Undivided Attention	2	9	6	67	3	33	8	6	75	2	25
		3	14	12	86	2	14	14	12	86	2	14
		4	17	12	71	5	29	16	13	81	3	19
		5	11	7	64	4	36	12	12	100	0	0
	Reads Again	2	9	6	67	3	33	8	7	87	1	13
		3	14	7	50	7	50	14	9	64	5	36
		4	17	14	82	3	18	16	12	75	4	25
		5	11	8	73	3	27	12	10	83	2	17
	Chooses Best Answer	2	9	7	78	2	22	8	7	87	1	13
		3	14	13	93	1	7	14	7	50	7	50
		4	17	14	82	3	18	16	9	56	7	44
		5	11	5	46	6	64	12	9	75	3	25
Evaluation	Goes Back	2	9	4	44	5	56	8	5	63	3	37
		3	14	4	29	10	71	14	9	64	5	36
		4	17	9	53	8	47	16	13	81	3	19
		5	11	6	54	5	46	12	11	92	1	8
	Looks for Hints of Success	2	9	9	100	0	0	8	8	100	0	0
		3	14	14	100	0	0	14	9	64	5	36
		4	17	17	100	0	0	16	11	69	5	31
		5	11	11	100	0	0	12	11	92	1	8

Notes. These constructs were evaluated by observation (Observed vs. Not Observed) using an adaptation of the Jr. MAI (Sperling, et al., 2002) and the original MAI scale (Schraw & Dennison, 1994).

Table C2

Frequencies of Technical Skills, and Self-Efficacy in Elementary Students in Grades 2-5

			Computer					Paper				
				Observed		Not Observed			Observed		Not Observed	
Dimension	**Observation Items**	**Grade**	**N**	**Count**	**%**	**Count**	**%**	**N**	**Count**	**%**	**Count**	**%**
Technical Skills	Knows How to Orient	2	9	8	89	1	11	8	8	100	0	0
		3	14	12	86	2	14	14	6	43	8	57
		4	17	16	94	1	6	16	16	100	0	0
		5	11	11	100	0	0	12	12	100	0	0
	Knows How to Use Computer Mouse	2	9	9	100	0	0	8	n/a			
		3	14	16	94	1	6	14				
		4	17	0	0	0	0	16				
		5	11	11	100	0	0	12				
	Knows Where to Start and Finish	2	9	8	89	1	11	8	8	100	0	0
		3	14	14	100	0	0	14	14	100	0	0
		4	17	16	94	1	6	16	16	100	0	0
		5	11	11	100	0	0	12	12	100	0	0

Notes. These constructs were evaluated by observation (Observed vs. Not Observed) using an adaptation of the Jr. MAI (Sperling, et al., 2002) and the original MAI scale (Schraw & Dennison, 1994).

Table C2 (continued)

			Computer					Paper				
				Observed		Not Observed			Observed		Not Observed	
Dimension	**Observation Items**	**Grade**	**N**	**Count**	**%**	**Count**	**%**	**N**	**Count**	**%**	**Count**	**%**
Self-Efficacy	Can Understand Content	2	9	7	78	2	22	8	7	88	1	13
		3	14	12	86	2	14	14	6	43	8	57
		4	17	14	82	3	18	16	9	56	7	44
		5	11	4	36	7	64	12	8	67	4	33
	Confident with Reading Skills	2	9	8	89	1	11	8	8	100	0	0
		3	14	14	100	0	0	14	12	86	2	14
		4	17	16	94	1	6	16	15	94	1	6
		5	11	11	100	0	0	12	11	92	1	8
	Can Complete	2	9	8	89	1	11	8	6	43	8	57
		3	14	14	100	0	0	14	14	100	0	0
		4	17	17	100	0	0	16	15	94	1	6
		5	11	11	100	0	0	12	12	100	0	0

Notes. These constructs were evaluated by observation (Observed vs. Not Observed) using an adaptation of the Jr. MAI (Sperling, et al., 2002) and the original MAI scale (Schraw & Dennison, 1994).

APPENDIX D

EXAMPLE OF i-READY READING ASSIGNMENT

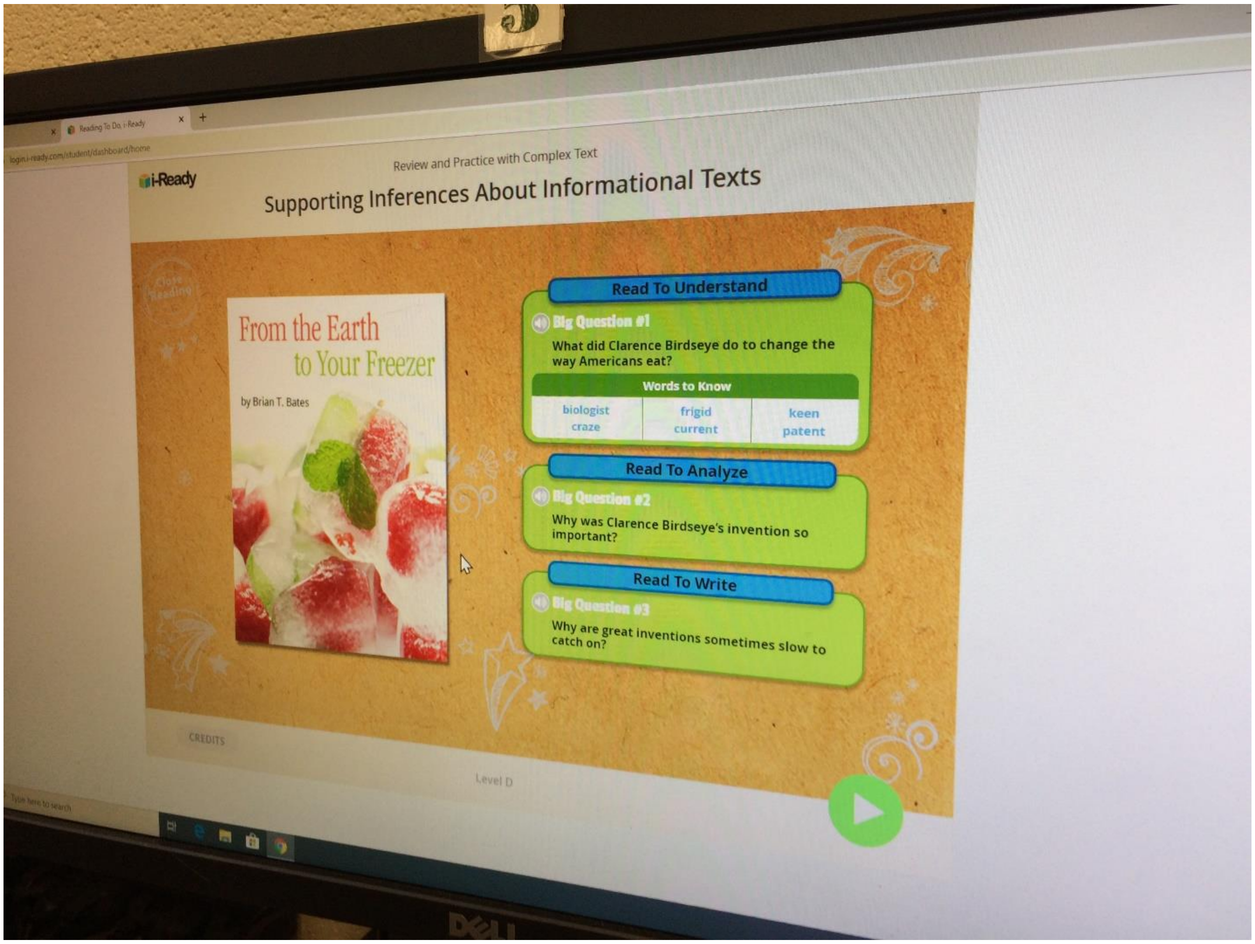

Figure D1. *Sample i-Ready Reading Comprehension Assignment for Grade 4.*

APPENDIX E

READING CATEGORIES AND TOPICS PER GRADE AND CONDITION

Table E1

Reading Categories and Topics in the Computer Condition

Grade	Computer Condition
2nd grade	Describe Connections with Events
	Close Reading: Juan Bobo Goes to Work
	Explain How Images Support Text: Pizza Making
	Describing Connections between Scientific Ideas: Wiggling Worms at Work
	Vocabulary: Working with Words: Act, allow, many, safe
	Vocabulary: Working with Words: Deal, prefer, serious, discuss, terrible
	Vocabulary: Working with Words: Decrease, convince, arrive, numerous
	Vocabulary: Working with Words: Springtime
3rd grade	Comprehension: An Argument: A Bear that is Weird
	Close Reading: Read to Understand-Analyze-Write: Chubbo's Pool
	Comprehension: Close Reading: Culture & Foods
	Comprehension: Ferris Wheel & Heating Up with Body Heat
	Close Reading: Review and Practice with Complex Text: From the Earth to Your Freezer
	Comprehension: Helping Hands & Super Gloves
	Phonics: Long O with Sneaky E
	Vocabulary: Prefix (re) & Vowel sound (out, ou, ow) & Suffix (ly)
	Phonics: Long O: Reading about Dress for the Cold
	Close Reading: Comprehension; Determining the Theme of a Story: Riding Freedom
	Comprehension: Stage Coach
	Tutorial: Understand Characters
	Vocabulary: Working with Words: Yoop-O-Gram

Table E1 (continued)

Grade	Computer Condition
4th grade	Describe How Characters Act: Astronauts & Racing for Olympic Gold
	Close Reading: Describing Characters
	Comprehension: Rescuing Orphan Elephants
	Determine Word Meaning
	Determine Word Meaning Using Prefixes & Suffixes -al and -ly
	Tutorial: Distinguish Points of View in a Story
	Comprehension: Elements of Plays: Elena, Frog & Mr. Prince
	Comprehension (Close Reading): Describing Cause and Effect: Flying with Artic Terms
	Close Reading: Review and Practice with Complex Text: From the Earth to Your Freezer
	Vocabulary: Phonics for soft sound g
	Comprehension: Supporting Inferences About Literary Texts
	Summarizing Literary Text: Turkey Leg Night
	Comprehension: Understanding Technical & Scientific Texts
	Meanings of words: Inter- and anti-
	Comprehension: Connecting Words & Pictures: Zarabunga
5th grade	Bangkok Summer
	Using Details to Support Inferences: Bicycles
	Close Reading: Recounting Stories: Joseph and the Beautiful Cloth
	Vocabulary: Combine Words & Sentences
	Close Reading: Historical Texts: Egypt, Kush, Aksum
	Comprehension: Describing Cause and Effect: Flying with Artic Terms
	Close Reading: Juan Bobo Goes to Work
	Close Reading: Recounting Stories: Jose and the Beautiful Cloth
	Comprehension: Use Words and Pictures in a Text: Sun Power & Pedal Power
	Comprehension: Finding Main Ideas and Details in Informational Text: Weather

Table E2

Reading Categories and Topics in the Paper Condition

Grade	Paper Condition
2nd grade	Magazine Article: Apple Picking Time
	Magazine Article: Homes Around the World
	Play: Stage Freight
	Science Article: Bugs Nature's Time Machine
3rd grade	Epic: The Cyclops
	Magazine Article: Apple Picking Time
	Review: Snow Sculpture Contest
	Science Article: Frozen Deserts
	Science Article: From Oddball to All-Stars
	The Great Inca Road
4th grade	Realistic Fiction: Baseball Lessons
	Folktale: Juvadi and the Princess
	Making a Rhino Bank
	The House by the Side of the Road
	Folktale: The Monkeys and the Moon and The King's Fire Dogs
	The Sound of Money
5th grade	A Brief History of the Internet
	How we Speak
	Mystery of the Old Sea Chest and Mile-High Mystery
	Myth: From Phaeton
	Night Walk
	The Story of Sir Gareth & Lynette
	Tsunamis & Hurricanes

APPENDIX F

RAW QUALITATIVE DATA BY CONSTRUCT, CONDITION, AND GRADE

Table F1

Raw Qualitative Data from Observations

Regulation of Cognition Constructs	Condition	2nd Grade	3rd Grade	4th Grade	5th Grade
Planning	Computer	Read entire text, words, definitions	Read entire text, words, definitions Gradual read Point mouse in word	Gradual read on their own Point mouse in word	Character narration
	Paper	Pinpoint words, number rows/verses	Look at entire text and questions	Passage and topic first, pause and ponder	Look at entire assignment, ponder
Monitoring	Computer	Ask questions to self or others (researchers), repeat difficult words Emotions	Context clues	Ask questions to others, await computer feedback, review	Await computer feedback, review
	Paper	Ask questions to self or others Emotions	Context clues, no attention to info in boxes	How to do questions	How to do questions

Table F1 (continued)

Regulation of Cognition Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Control	Computer	Visual cues, animated characters Embedded charts vs. new chart Eye regression Character narration	Visual cues, animated characters Embedded charts vs. new chart Eye regression Mouth words	Visual cues, animated characters Embedded charts vs. new chart Eye regression Character narration & on their own	Visual cues, animated characters Embedded charts vs. new chart Short on their own-long character
	Paper	No read aloud Close reader habits	Mouthing words Reread for writing	No read aloud Title, bold words, hints	Response elimination
Evaluation	Computer	Go back	Computer feedback	Go back Trial and error	Go back Computer prompts
	Paper	Go back	Go back	Go back	Go back

Table F1 (continued)

Motivation Constructs	Condition	2nd Grade	3rd Grade	4th Grade	5th Grade
Technical Skills	Computer	Navigation	Adept	Adept Aimless hovering	Navigation
	Paper	Orientation	Orientation	Orientation	Orientation
Self-Efficacy	Computer	Character narration first	Confident Some mistakes	Know where to click and why Overconfidence	Overconfidence
	Paper	Confident Some mistakes in write	Confident Incomplete and irrelevant	Confident Incomplete and irrelevant	Confident, but reread

Table F2

Raw Qualitative Data from Semi-Structured Interviews

Regulation of Cognition Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Planning	Computer	No planning. Some concentrating	Computer characters Process of elimination Annotation = cheating	Reliance on teacher instruction Annotation = cheating Questions about main idea	Computer characters to explain and pronounce
	Paper	Ask questions to self Previous completion	Context clues Annotation: no; reliance on own mind	Circle Process of elimination Some annotations as a reminder	Annotations = off-track activity
Monitoring	Computer	No questions to self Reread for correctness	No questions to self Recheck Reread (computer characters)	Ask questions Reliance on computer	Student – computer = conflict
	Paper	Questions about performance	Assignment returned	Ask questions Reread	Context clues

Table F2 (continued)

Regulation of Cognition Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Control	Computer	No diagrams Info in sidebars Context clues Splitting word up	No diagrams Info in sidebars Context clues Splitting word up	No diagrams; Diagrams = mental trace to remember Cues; hints; read it buttons Computer characters	No diagrams Cues; hints; read it buttons Computer characters
	Paper	Diagrams → haven't learned Bold print; captions Circling; underlining Read aloud = give away answer	Diagrams → haven't learned Circling; underlining Read aloud = class interruption, read inside head	Bold words; italics Read aloud = not doing things in head Emotional states	Read aloud = not understanding
Evaluation	Computer	Go back to story Ask questions to self	Ask teacher for unknowns Progress score	Reread on own and via computer program	Go back Computer status report
	Paper	Reread No knowledge of progress	Reread Look around a word	Go back Grade to evaluate learning	Go back Grade to evaluate learning

Table F2 (continued)

Knowledge of Cognition Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Declarative Knowledge (facts and concepts)	Computer	Interest in topic = Focus and engagement Aware of unknowns Teacher assistance and encouragement	Interest in topic = Focus and engagement Incomplete tasks Teacher guidance	Interest in topic = Focus and engagement Teacher guidance Write down = remembering	Interest in topic = Focus and engagement Read-listen-find clues Reading = understanding
	Paper	Disinterest in topic = less clarity Teacher encouragement	Disinterest in topic = less clarity Reread to understand Process of association Challenging topic = remembering	Disinterest in topic = less clarity Follow teacher's directions	Disinterest in topic = less clarity Think question – answer No teacher guidance
Conditional Knowledge (strategies use and purpose)	Computer	Concentration	Familiarity with topic	High grades Attention to features Teacher instruction = memory	Familiarity; background knowledge Personal best
	Paper	Familiarity = better performance Good grades = incentive	Familiarity = better performance	Performance Familiarity = not comprehension	Familiarity; background knowledge Questions-passage-questions Feelings of enjoyment

Table F2 (continued)

Knowledge of Cognition Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Procedural Knowledge (awareness of strategies)	Computer	Feelings of fear = performance	Feelings of fear = performance	Questions-think-read passage No annotations = not enough comprehension	Information buttons Familiarity = no standard way Failure
	Paper	Teacher-driven	Reread Teacher-driven	Title, clues, questions Annotations = remember 5 Ws mnemonic strategy	Low-utility methods = understanding
Motivation Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Technical Skills	Computer	Navigation ease Teacher assistance	Navigation ease	Navigation ease	Navigation ease
	Paper	Know your way around Teacher guidance Numbering; indentation	Know your way around Teacher guidance Numbering; indentation	Know your way around Numbering; indentation	Know your way around
Self-Efficacy	Computer	Discrepancy between computer and own reading = less confidence Performance expectations	Family influence to read Computer characters to guide	Computer questions Misplaced words = work harder	Performance outcomes Overconfidence

Table F2 (continued)

Motivation constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Self-Efficacy	Paper	Topic + genre = partial confidence Context clues; prior knowledge; memory skills	Reading favorite = ability Teacher assistance Break words Close reading habits	Reading mastery Word parts	Reading mastery Unfamiliarity with topic Length = rewarding reading
Emerging Constructs	**Condition**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
	Computer	For unclear elements	For unclear elements	Computer Pronunciation	No clear results
Sounding out	Paper	For unclear elements but not comprehension	For unclear elements = figure out	For unclear elements = spell out	
Distractions	Computer		No concentration	No concentration Ask teacher assistance	

APPENDIX G

INTERNAL CONSISTENCY RESULTS FOR COMBINED AND ITEMIZED SRL METACOGNITIVE CONSTRUCTS

Table G1

Internal Consistency Results for SRL Metacognitive Constructs (n = 48)

	Computer Condition			Paper Condition		
	M	*SD*	α	*M*	*SD*	α
Regulation of Cognition Constructs	11.31	3.66	**0.66**	11.21	3.94	**0.72**
Planning	2.54	1.34	0.30	2.66	1.24	0.33
Monitoring	1.87	1.14	0.23	1.96	1.13	0.20
Control	2.10	0.95	0.09	2.29	1.18	0.22
Evaluation	4.79	1.80	0.58	4.25	1.80	0.64
Knowledge of Cognition Constructs	10.81	2.83	**0.68**	10.94	2.44	**0.57**
Declarative Knowledge	5.79	1.47	0.41	5.88	1.38	0.41
Conditional Knowledge	2.83	0.83	-0.56	3.04	0.74	-0.05
Procedural Knowledge	2.19	1.12	0.60	2.00	1.08	0.15
Motivation Constructs	14.52	2.43	**0.71**	11.94	2.36	**0.65**
Technical Skills	5.46	0.80	0.32	3.27	0.89	0.75
Self-Efficacy	4.85	0.97	0.27	4.54	1.05	0.47
Reading Motivation	4.21	1.32	0.72	4.13	1.45	0.69

Notes. Internal consistency is represented by Cronbach's alpha (α). *M* represents the mean, and *SD* represents the standard deviation of each combined construct and its associated dimensions.

APPENDIX H

CORRELATIONS FOR ITEMIZED SRL METACOGNITIVE CONSTRUCTS

Table H1

Itemized Correlations for Constructs from Interviews for Final Participating Students (n = 48)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1. Technical Skills Computer	1									
2. Self-Efficacy Computer	.28	1								
3. Declarative Knowledge Computer	.12	.56**	1							
4. Conditional Knowledge Computer	.02	.29*	.42**	1						
5. Procedural Knowledge Computer	.26	.55**	.55**	.56**	1					
6. Planning Computer	.16	.28	.37**	.37**	.39**	1				
7. Monitoring Computer	.06	.16	.29*	.34*	.27	.24	1			
8. Control Computer	.19	.27	.37*	.21	.22	.12	.21	1		
9. Evaluation Computer	.20	.58**	.49**	.33*	.54**	.41**	.54**	.15	1	
10. Technical Skills Paper	.27	.22	.19	.12	.33*	.12	.14	.32*	.19	1
11. Self-Efficacy Paper	.10	.62**	.59**	.42**	.58**	.24	.24	.03	.49**	.34*
12. Declarative Knowledge Paper	.27	.47**	.63**	.37**	.48**	.25	.34*	.25	.57**	.24
13. Conditional Knowledge Paper	.25	.39**	.18	.36*	.53**	-.002	.16	-.04	.36*	.11
14. Procedural Knowledge Paper	.33*	.33*	.22	.34*	.28	.00	.42**	.22	.49**	.22
15. Planning Paper	.05	.10	.14	.41**	.31*	.39**	.19	-.09	.21	-.16
16. Monitoring Paper	-.05	.09	.37*	.19	.28	.51**	.39**	.2	.32*	-.03
17. Control Paper	.28	.28	.08	.35*	.44**	.25	.08	.35*	.23	.11
18. Evaluation Paper	.08	.38**	.46**	.31*	.46**	.47**	.46**	.02	.65**	-.07
19. Reading Motivation Computer	.25	.64**	.61**	.30*	.46**	.24	.39**	.22	.62**	.01
20. Reading Motivation Paper	.28	.41**	.44**	.12	.38**	.22	.29*	-.03	.45**	-.19

Notes. * $p < .05$; ** $p < .01$.

Table H1 (continued)

	11	12	13	14	15	16	17	18	19
1. Technical Skills Computer									
2. Self-Efficacy Computer									
3. Declarative Knowledge Computer									
4. Conditional Knowledge Computer									
5. Procedural Knowledge Computer									
6. Planning Computer									
7. Monitoring Computer									
8. Control Computer									
9. Evaluation Computer									
10. Technical Skills Paper									
11. Self-Efficacy Paper	1								
12. Declarative Knowledge Paper	.62**	1							
13. Conditional Knowledge Paper	.46**	.34*	1						
14. Procedural Knowledge Paper	.23	.35*	.32*	1					
15. Planning Paper	.04	.21	.29*	.21	1				
16. Monitoring Paper	.15	.31*	-.07	.09	.37*	1			
17. Control Paper	.18	.29*	.28	.41**	.46**	.09	1		
18. Evaluation Paper	.35*	.41**	.34*	.35*	.42**	.57**	.28	1	
19. Reading Motivation Computer	.59**	.62**	.29*	.37*	.04	.13	.19	.42**	1
20. Reading Motivation Paper	.46**	.47**	.25	.35*	.10	.28	.07	.37**	.76**

Notes. * $p < .05$; ** $p < .01$